

US Patent & Trademark Office

Patent Public Search | Text View

United States Patent Application Publication

20250264650

Kind Code

A1

Publication Date

August 21, 2025

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IMAGING MODULE, ASSEMBLING METHOD THEREFOR, AND HEAD MOUNT DISPLAY

Abstract

Disclosed are an imaging module, an assembling method therefor, and a head mount display. The imaging module includes: a display screen—, an imaging lens—, and a first polarization converter—. The display screen—is configured for emitting a light. The imaging lens—is provided in a light-emergent direction of the display screen. The first polarization converter—is provided on the imaging lens; lights emitted by the display screen—in different fields of view include chief lights located in the center which all pass through a central region of an exit pupil position.

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Appl. No.: 18/575588

Filed (or PCT Filed): June 21, 2022

PCT No.: PCT/CN2022/100047

Foreign Application Priority Data

CN 202110740120.5

Jun. 30, 2021

CN 202111460503.3

Dec. 01, 2021

Publication Classification

Int. Cl.: G02B5/30 (20060101); G02B27/01 (20060101)

U.S. Cl.:

CPC G02B5/3083 (20130101); G02B27/0172 (20130101); G02B2027/0118 (20130101)

Background/Summary

CROSS-REFERENCE TO RELATED APPLICATIONS [0001] The present disclosure is a National Stage of International Application No. PCT/CN2022/100047, filed on Jun. 21, 2022, which claims priority to Chinese patent application No. 202110740120.5, filed on Jun. 30, 2021 and entitled “IMAGING MODULE, ASSEMBLING METHOD THEREFOR AND HEAD MOUNT DISPLAY”, and claims priority to Chinese patent application No. 202111460503.3, filed on Dec. 1, 2021, which are incorporated herein by reference in their entireties.

TECHNICAL FIELD

[0002] The present disclosure relates to the field of optical display technology, and in particular to an imaging module, an assembling method therefor and a head mount display.

BACKGROUND

[0003] In a head mount display (HMD), in order to reduce the volume of the whole device, a catadioptric optical path is usually designed inside the head mount display, so that light is propagated back and forth many times in a limited space. In order to ensure that the light can be refracted and reflected smoothly, the light needs to be converted to a uniform polarization state. However, when the light from the display screen passes through some optical elements, its incident angle changes, and different incident angles will cause light to be converted into different polarization states. These lights in different states other than the uniform polarization state form stray light, which may degrade the clarity of imaging.

SUMMARY

[0004] In view of the above, aiming at the problem that the stray light, which is formed by the existing lights in different incident angles, may degrade clarity of imaging, it is necessary to provide an imaging module, an assembling method therefor and a head mount display intended for reducing the stray light and ensuring users a clear imaging picture.

[0005] To achieve the above objective, the present disclosure proposes an imaging module, comprising: [0006] a display screen configured for emitting a light; [0007] an imaging lens provided in a light-emergent direction of the display screen; and [0008] a first polarization converter provided on the imaging lens, lights emitted by the display screen in different fields of view comprise chief lights located in the center which all pass through a central region of an exit pupil position.

[0009] Optionally, incident angles of the chief lights emitted by the display screen in different fields of view to a surface of the first polarization converter are less than or equal to 5° .

[0010] Optionally, the chief lights comprise a central chief light emitted from a central field of view of the display screen and a marginal chief light emitted from a marginal field of view of the display screen, an incident angle of the central chief light first incident to the first polarization converter is a first central incident angle being α_1 , satisfying $\alpha_1=0$; [0011] an incident angle of the marginal chief light first incident to the first polarization converter is a first marginal incident angle being β_1 , satisfying $0^{\circ}\leq\beta_1\leq 5^{\circ}$.

[0012] Optionally, the imaging lens is provided with a light-incident surface to which the light is incident and a light-emergent surface from which the light is emergent, and the first polarization converter is provided on the light-incident surface or on the light-emergent surface of the imaging

lens.

[0013] Optionally, the imaging module further comprises a second polarization converter provided on the light-emergent surface of the imaging lens, the first polarization converter is provided on the light-incident surface of the imaging lens, and both the light-incident surface and the light-emergent surface of the imaging lens are flat surfaces; [0014] an incident angle of the central chief light first incident to the second polarization converter is a second central incident angle being α_2 , satisfying $\alpha_2=0$; [0015] an incident angle of the marginal chief light first incident to the second polarization converter is a second marginal incident angle being β_2 , satisfying $0^\circ \leq \beta_2 \leq 5^\circ$.

[0016] Optionally, the imaging lens comprises a first lens and a second lens which are sequentially provided along a light propagation direction, are made of the same material and are glued to each other; the first polarization converter is provided on a light-incident surface of the first lens, and the second polarization converter is provided on a light-emergent surface of the second lens.

[0017] Optionally, the first polarization converter and the second polarization converter are both phase retarders, and the imaging module further comprises: [0018] a linear polarizer provided on a side of the first polarization converter facing away from the first lens; [0019] a beam-splitter provided between the first lens and the second lens, and [0020] a polarization reflector provided on a side of the second polarization converter facing away from the second lens.

[0021] Optionally, the imaging module further comprises a third polarization converter which is a phase retarder and is provided between the linear polarizer and the display screen.

[0022] Optionally, the imaging module further comprises a third lens which is a positive lens and is provided on a side of the imaging lens facing away from the display screen;

[0023] a direction perpendicular to a direction of an optical axis of the imaging module is defined as a height direction, the imaging module has a height of D_1 , and the third lens has a height of D_2 , satisfying: $D_2 < D_1$.

[0024] In addition, for solving the above problem, the present disclosure also provides an assembling method for an imaging module, the assembling method is applied for the above imaging module, the first polarization converter is glued to the imaging lens, and the assembling method comprises: [0025] adjusting a gluing angle of the first polarization converter on the imaging lens so as to determine a gluing position of the first polarization converter when stray light is at a low ebb; and [0026] gluing and fixing the first polarization converter according to determined gluing position of the first polarization converter.

[0027] In addition, for solving the above problem, the present disclosure also provides a head mount display, wherein the head mount display comprises a housing and the above imaging module, and the imaging module is provided within the housing.

[0028] In the technical solution proposed in the present embodiment, the display screen emits light to the imaging lens. The imaging lens is used to transmit the light of the display screen and perform imaging at exit pupil position via the human eye. The first polarization converter is used to change the polarization state of the light. The chief lights of the display screen under different fields of view pass through the center of the exit pupil position, and as such it is understood that the imaging module is understood to be an image side telecentric system, and that the chief lights emitted under different fields of view are parallel or substantially parallel to each other. Thus, the chief lights emitted from the display screen at different positions have a smaller incident angle on the surface of the first polarization converter. In this case, it is possible to ensure that the incident angles are as uniform as possible, to reduce the occurrence of other incident angles, and thus to reduce occurrence of lights in other polarization states, which in turn reduces occurrence of the stray light, and ensures that the user obtains a clear imaging picture.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

[0029] In order to clearly illustrate embodiments of the present disclosure or technical solutions in the prior art, accompanying drawings that need to be used in description of the embodiments or the prior art will be briefly introduced as follows. Obviously, drawings in following description are only the embodiments of the present disclosure. For those skilled in the art, other drawings can also be obtained according to the disclosed drawings without creative efforts.

[0030] FIG. 1 shows a schematic structural illustration of an optical module in an embodiment of the present disclosure;

[0031] FIG. 2 is a schematic structural illustration of a portion of the imaging lens in FIG. 1;

[0032] FIG. 3 is a schematic diagram of the heights of the imaging lens and the third lens in FIG. 1;

[0033] FIG. 4 is a schematic diagram of steps of an assembling method of the imaging module of the present application;

[0034] FIG. 5 is a graph of modulation transfer function of the imaging module in FIG. 1 at 450 nm;

[0035] FIG. 6 is a graph of modulation transfer function of the imaging module in FIG. 1 at 540 nm;

[0036] FIG. 7 is a graph of modulation transfer function of the imaging module in FIG. 1 at 610 nm;

DESCRIPTION OF REFERENCE SIGNS

TABLE-US-00001 No. Name No. Name 10 display screen 30 first polarization converter 101 human eye 40 second polarization converter 110 chief light 50 linear polarizer 111 central chief light 60 beam-splitter 112 marginal chief light 70 polarization reflector 20 imaging lens 80 third polarization converter 210 first lens 90 third lens 220 second lens

[0037] The implementation of the objects, functional features and advantages of the present disclosure will be further described in connection with the embodiments, with reference to the accompanying drawings.

DETAILED DESCRIPTION

[0038] Technical solutions in the embodiments of the present disclosure are described below with reference to the accompanying drawings in the embodiments of the present disclosure. Apparently, the described embodiments are merely some rather than all of the embodiments of the present disclosure. All other embodiments, acquired by those of ordinary skill in the art based on the embodiments of the present disclosure without any creative work, should fall into the protection scope of the present disclosure.

[0039] It should be noted that all directional indications (such as up, down, left, right, front, back . . .) in the embodiment of the present disclosure are used only to explain the relative positional relationship, movement, etc., between the parts in a particular attitude (as shown in the accompanying drawings), and the directional indications are changed accordingly if that particular attitude is changed.

[0040] In addition, terms “first” and “second” involved in the present disclosure are only used for descriptive purposes and should not be understood as indicating or implying relative importance or implying a number of indicated technical features. Therefore, a feature delimited with “first”, “second” may expressly or implicitly include at least one of those features. In a description of the present disclosure, “a plurality” means at least two, such as two, three, etc., unless expressly and specifically defined otherwise.

[0041] In the present disclosure, unless expressly specified and limited otherwise, terms “connected”, “fixed” and other terms should be interpreted in a broad sense, for example, it can be a fixed connection, a detachable connection, or an integrated; it can be a mechanical connection or an electrical connection; it can be directly connected, or indirectly connected through an intermediate medium, and it can be an internal communication between two elements or an

interaction relationship between the two elements, unless otherwise explicitly defined. For those of ordinary skill in the art, specific meanings of the above terms in the present disclosure can be understood according to specific situations.

[0042] In addition, the technical solutions between the various embodiments of the present disclosure may be combined with each other, but it must be based on the fact that it can be realized by a person of ordinary skill in the art. When the combination of technical solutions appears to be contradictory or unattainable, it should be considered that such combination of technical solutions does not exist and is not within the scope of protection claimed in the present disclosure.

[0043] In related technology, the head mount device may provide a virtualized experience for the user, but the current head mount devices are large in size, and in order to reduce the volume of the head mount device, a catadioptric optical path is usually designed inside the head mount display, so that light is transmitted back and forth many times in a limited space. At the same time, in order to ensure that the light can be refracted and reflected smoothly, the light needs to be converted to a uniform polarization state. However, when the light from the display screen passes through some optical elements, its incident angle will change, in particularly when passing through some polarization converters, and different incident angles will lead to light into different polarization states. These lights in a different state than the uniform polarization state form stray light, which may degrade the clarity of imaging.

[0044] For solving the above problem, please refer to FIGS. 1 and 2, the present disclosure provides an imaging module, which comprises a display screen **10**, an imaging lens **20** and a first phase retarder **30**. The display screen **10** is configured for emitting light, the imaging lens **20** is provided in a light-emergent direction of the display screen **10**, the first polarization converter **30** is provided on the imaging lens **20**, the imaging lens **20** is provided with a light-incident surface and a light-emergent surface, and the first polarization converter **30** is provided on the light-incident surface or on the light-emergent surface of the imaging lens **20**.

[0045] Here, the display screen **10** comprises pixel points arranged in rows and columns, each of which is a light emitting unit. The light emitted from the light emitting units forms a conical diffused light which comprises a chief light **110** emitted from the center of each light emitting unit and an auxiliary light located at the periphery of the chief light **110** and having a weak light intensity. The chief light **110** occupies most of the light intensity of the diffused light, and controls the incident angle of the chief light **110**, which is equivalent to controlling the incident angle of all the lights of the display screen. In this way, the incident angle of the chief light **110**, and thus of the entire light, is guaranteed. In addition, the display screen **10** includes a variety of display principles. For example, the principle of the display screen **10** includes LCD (Liquid Crystal Display), or LED (ray Emitting Diode), OLED (Organic Light-Emitting Diode), Micro-OLED (Micro-Organic Light-Emitting Diode), ULED (Ultra. Light Emitting Diode), or DMD (Digital Micromirror Device), etc.

[0046] The imaging lens **20** is provided in a light-emergent direction of the display screen **10**, and functions to magnify and resolve the light. The area of the light-emergent surface of the display screen **10** is small, e.g., a few inches in size in a VR (Virtual Reality) display device or an AR (Augmented Reality) display device. In order to ensure that the user obtains a magnified display picture, the light needs to be magnified and the user is ensured by the imaging lens **20** to obtain a magnified picture that can be recognized. Wherein the imaging lens **20** may be a single lens or a combination of multiple lenses.

[0047] The first polarization converter **30** is provided on the imaging lens **20**, and functions to change polarization state of the light, e.g., to convert the light to linearly polarized light, or to convert the light to circularly polarized light, or to elliptically polarized light, and also to convert the polarization state of the light between the linearly polarized state and the circularly polarized state. The light passes through the imaging lens and converges to form an image after passing through the human eye at the exit pupil position, and the light emitted by the display screen under

different fields of view comprises chief lights **110** at the center, which all pass through the central region of the exit pupil position. Ideally, the chief lights **110** pass through the center point of the exit pupil position, i.e., the chief lights **110** pass through one point. It is also possible that the chief lights **110** pass through a circular central region centered on the center point of the exit pupil position and formed with a certain radius value. For example, the central region is a circular region formed by taking the center point of the exit pupil position as a circular point and taking one fifth of the height of the exit pupil image as a radius. The chief lights passing through the central region are substantially perpendicular to the surface of the first polarization converter **30**. The first polarization converter **30** may be independent optical elements or a film structure, and is bonded to the imaging lens **20** through an optical adhesive.

[0048] In the technical solution proposed in the present embodiment, the display screen **10** emits light to the imaging lens **20**. The imaging lens **20** is used to transmit the light of the display screen **10** and converge it at the position of the human eye **101**. The first polarization converter **30** is used to change the polarization state of the light. The chief lights **110** of the display screen **10** under different fields of view pass through the center of the exit pupil position, and as such it is understood that the imaging module is understood to be an image side telecentric system, and that the chief lights **110** emitted under different fields of view are parallel or substantially parallel to each other. Thus, the chief lights **110** emitted from the display screen **10** at different positions have a smaller incident angle on the surface of the first polarization converter **30**. In this case, it is possible to ensure that the incident angles are as uniform as possible, to reduce the occurrence of other incident angles, and thus to reduce occurrence of lights in other polarization states, which in turn reduces occurrence of the stray light, and ensures that the user obtains a clear imaging picture.

[0049] In the above embodiment, in order to further limit the incident angle of the chief light and reduce the generation of the spray light, the incident angle of the chief light **110** emitted from the display screen at different positions on the surface of the first polarization converter is less than or equal to 5° , and specifically, the incident angle is between 0° and 5° , for example, the incident angle may be 0° , 1° , 2° , 3° , 4° and 5° , or may be a decimal value of incident angle. As can be seen, the chief lights **110** are substantially parallel to each other, and even at the edge position of the display screen, the tilt angle of the chief lights **110** is small, and the forward direction of the chief lights **110** is substantially orthogonal to the surface of the first polarization converter, so as to reduce the generation of the stray light.

[0050] In the above embodiment, the light is more likely to be diffused at the edge position of the display screen **10**, and thus the light at the edge position is more likely to form a stray light. For further reducing the stray light, the chief lights **110** comprise a central chief light **111** emitted from a central field of view of the display screen **10** and a marginal chief light **112** emitted from a marginal field of view of the display screen **10**, an incident angle of the central chief light **111** first incident to the first polarization converter **30** is a first central incident angle being α_1 , satisfying $\alpha_1=0$. It can be seen that the central chief light **111** is vertically incident to the first polarization converter. The light also comprises a marginal chief light **112** emitted at an edge position of the display screen **10**. An incident angle of the marginal chief light **112** first incident to the first polarization converter **30** is a first marginal incident angle being β_1 , satisfying $0^\circ \leq \beta_1 \leq 5^\circ$. For example, β_1 of the first marginal incident angle may be 0° , 1° , 2° , 3° , 4° and 5° , or may be a decimal angle value. That is to say, for reducing stray light, the light emitted at edge position of the display screen **10** is between 0° and 5° . The first marginal incident angle is within the range of the angle, and by the first marginal incident angle being equal to 0° or close to 0° so as to reduce lights incident at other angles, it is guaranteed that lights passing through the first polarization converter **30** have the same or similar polarization state, thereby reducing the stray light. It should be noted that the display screen **10** has an upper end and a lower end, and with the optical axis of the display screen **10** as the center, if a light emitted from the upper end of the display screen **10** has a positive incident angle at the surface of the first polarization converter **30**, then a light emitted from the

lower end of the display screen **10** has a negative incident angle at the surface of the second polarization converter **40**. It can be understood that the incident angle of the light emitted from the upper end of the display screen **10** is between 0° and 5° , and the incident angle of the light emitted from the lower end of the display screen **10** is between 0° and -5° . Since the lights emitted from the display screen **10** are substantially parallel to their optical axis, the lights are theoretically focused at a farther position, and therefore, an optical system of the imaging module is formed, which is also referred to as an image side telecentric system.

[0051] In an embodiment of the present disclosure, to make the position of the first polarization converter **30** more flexible, the imaging lens **20** is provided with a light-incident surface to which the light is incident and a light-emergent surface from which the light is emergent, and the first polarization converter **30** is provided on the light-incident surface or on the light-emergent surface of the imaging lens **20**. It should be noted that both the light-incident surface and the light-emergent surface of the imaging lens **20** are flat surfaces, and the first polarization converter **30** is provided on either of them. The central chief light **111** is passed between two parallel flat surfaces, and the incident angle is not deflected. The first polarization converter **30** is provided on the light-incident surface of the imaging lens **20** and is closer to the display screen **10**. At this time, the divergence angle of the light is smaller, and it is easier to reduce stray light. The first polarization converter **30** is provided on the light-emergent surface of the imaging lens **20**, and lights are incident to the first polarization converter **30** after passing through the imaging lens **20**, such that the light resolved by the imaging lens **20** is incident to the first polarization converter **30**.

[0052] In another embodiment of the present disclosure, sometimes it is necessary to convert the polarization state of the light several times within the imaging module. The imaging module further comprises a second polarization converter **40** provided on the light-emergent surface of the imaging lens **20**, the first polarization converter **30** is provided on the light-incident surface of the imaging lens **20**; both the light-incident surface and the light-emergent surface of the imaging lens **20** are flat surfaces, with which it is possible to further ensure that the surface of the first polarization converter and the surface of the second polarization converter are perpendicular to the optical axis. By setting the first polarization converter **30** and the second polarization converter **40**, the polarization state of the light may be converted at least twice. In addition, in order to ensure that the generation of stray light on the surface of the second polarization converter **40** is also reduced, the central chief light **111** emitted from the display screen **10** is emitted to the second polarization converter **40** after passing through the first polarization converter **30**, the incident angle of the central chief light **111** first incident to the second polarization converter **40** is a second central incident angle being α_2 , satisfying $\alpha_2=0$; the incident angle of the marginal chief light **112** first incident to the second polarization converter **40** is a second marginal incident angle being β_2 , satisfying $0^\circ \leq \beta_2 \leq 5^\circ$. For example, β_2 of the second marginal incident angle may be 0° , 1° , 2° , 3° , 4° and 5° , or may be a decimal angle value. The mounting position of the second polarization converter **40** on the imaging lens **20** is also a flat surface, whereby the central chief light **111**, after being vertically incident on the light-incident surface of the imaging lens **20**, is vertically emitted from the light-emergent surface of the imaging lens **20**, and in turn, the incident angle of central chief light **111** at the second polarization converter **40** is also zero degree, that is, the second central incident angle α_2 is zero degrees. In the case of zero degrees, it is possible to ensure that the lights form a uniform polarization state and reduce the stray light. In addition, when the marginal chief light **112** also passes through two optical axes perpendicular to the display screen **10** in turn, the incident angle of the marginal chief light **112** changes only slightly or nothing, and the incident angle of the marginal chief light **112** is closer to 0° , thus reducing generation of stray light.

[0053] To further ensure that the light has the same incidence angles at the light-incident surface and the light-emergent surface of the imaging lens **20**, the imaging lens **20** comprises a first lens **210** and a second lens **220** which are sequentially provided along a light propagation direction and are made of the same material, e.g., both are glass or both are plastic. The first lens **210** and the

second lens **220** are glued to each other, the first polarization converter **30** is provided on a light-incident surface of the first lens **210**, and the second polarization converter **40** is provided on a light-emergent surface of the second lens **220**. In the case where the first lens **210** and the second lens **220** are made of the same material, the first lens **210** and the second lens **220** have the same refractive index, and the transmission of light in the first lens **210** is the same as that in the second lens **220**, thereby ensuring that the light has the same incident angle at the light-incident surface of the first lens **210** and the light-emergent surface of the second lens **220**. In addition, it should be noted that in order to magnify and resolve the light from the display screen **10**, it is also possible to set the light-emergent surface of the first lens **210** as a concave surface and set the light-incident surface of the second lens **220** as a convex surface, and thus the lights diverge as they pass the light-emergent surface of the first lens **210** and converge as they pass the light-incident surface of the second lens **220**. The original parallel lights are parallel again after the process of divergence and re-convergence, the incident angle does not change, but the diameter of the optical path is increased, so that the user can obtain the magnified image.

[0054] In another embodiment of the present disclosure, in order to reduce the size of the imaging module, the first polarization converter **30** and the second polarization converter **40** are both phase retarders, e.g., the first polarization converter **30** and the second polarization converter **40** are quarter waveforms. The imaging module further comprises: a linear polarizer **50**, a beam-splitter **60** and a polarization reflector **70**. The linear polarizer **50** is provided on a side of the first polarization converter **30** facing away from the first lens **210**; the beam-splitter **60** is provided between the first lens **210** and the second lens **220**, and can be adhesive or coated. The beam-splitter **60** may be provided on the first lens **210** or on the second lens **220**. The polarization reflector **70** is provided on a side of the second polarization converter **40** facing away from the second lens **220**. The transmission axis of the linear polarizer **50** is orthogonal to that of the polarization reflector **70**, the included angles between the optical axes of the first polarization converter **30** and the second polarization converter **40** and the transmission axis of the linear polarizer **50** are 45° , and the optical axis of the first polarization converter **30** is orthogonal to the that of the second polarization converter **40**. The display screen **10** emits light, the emitted light passes through the linear polarizer **50** and the first polarization converter **30** in turn, the polarization state of the emitted light is circularly polarized light, and the light, after passing through the first lens **210**, is then directed at the beam-splitter **60**. When passing through the beam-splitter **60**, a part of the light is reflected while the other part of the light is transmitted. The ratio of reflection to transmission may be 1:1, 2:1, or 1:2. For example, the beam-splitter **60** may be a polarization-reflecting film. The light transmitted through the beam-splitter **60** continues to propagate and passes through the second lens **220** to the second polarization converter **40**, where the circularly polarized light changes in polarization state and is converted to a linearly polarized light. The linearly polarized light is directed to the polarization reflector **70**. At this time, the vibrating direction of the linearly polarized light is different from the direction of the transmittance axis of the polarization reflector **70**, and therefore the light is reflected. The reflected light passes through the second polarization converter **40** and the second lens **220** in sequence, and is directed to the beam-splitter **60** again. When the light passes through the beam-splitter **60** again, the light is partially reflected toward the second polarization converter **40**. At this time, the light is converted to circularly polarized light, changes in polarization handedness after reflection, and is converted again to linearly polarized light after passing through the second polarization converter **40** again. At this time, the polarization direction of the linearly polarized light is the same as the direction of the transmission axis of the polarization reflector **70**, and in this process, the diameter of the optical path is continuously magnified. Through multiple refractions and reflections of the light, the image is magnified and transmitted in a limited space, which advantageously reduces the volume of the imaging module.

[0055] In one of embodiments of the present disclosure, in order to further reduce stray light, the imaging module further comprises a third polarization converter **80** which is a phase retarder, e.g.,

the third polarization converter **80** is a quarter wave plate. The third polarization converter **80** is provided between the linear polarizer **50** and the display screen **10**, and the optical axis thereof and the transmission axis of the linear polarizer **50** form an angle of 45° therebetween, which may be positive 45° or negative 45° . The 45° is to ensure that the light may be switched between circular and linear polarization. The light reflected by the linear polarizer **50** is converted into the circularly polarized light after passing through the third phase retarder and is changed in the polarization handedness after being reflected by the display screen **10** from left-handed to right-handed or from right-handed to left-handed. After the light passes through the third phase retard again, the circularly polarized light is converted into the linearly polarized light, and the polarization direction of the linearly polarized light is perpendicular to the transmission axis of the linear polarizer **50**, so that the light cannot pass through the linear polarizer **50**, thereby reducing the generation of stray light.

[0056] In one of embodiments of the present disclosure, the imaging module further comprises a third lens **90** which is a positive lens and is provided on a side of the imaging lens **20** facing away from the display screen **10**; a direction perpendicular to a direction of an optical axis of the imaging module is defined as a height direction, the imaging module **20** has a height of $D1$, and the third lens **90** has a height of $D2$, satisfying: $D2 < D1$. It can be seen that the effective height dimension of the third lens **90** is smaller than the effective height dimension of the imaging lens **20**. In this way, light needs to be bent at a large angle in the direction of the optical axis of the imaging module when directed to the third lens **90**. Also, since the third lens **90** has a positive optical power, the position where the light is converged is closer to the imaging module, and thus, the imaging position is closer. The imaging module has a more compact overall size and is also user-friendly.

[0057] Referring to FIG. **4**, the present disclosure also provides an assembling method for an imaging module, the assembling method is applied for the above imaging module, the first polarization converter is glued to the imaging lens, and the assembling method comprises:

[0058] Step **S10**, adjusting a gluing angle of the first polarization converter on the imaging lens so as to determine a gluing position of the first polarization converter when stray light is at a low ebb; providing an optical adhesive between the first polarization converter and the imaging lens, rotating the first polarization converter when the optical adhesive is not cured, wherein the optical axis of the first polarization converter also moves synchronously during the rotation, and finding the position of the first polarization converter when the stray light is minimum by observing the change of the stray light, and recording the position. In addition to observation, it is also possible to set the light intensity threshold of the stray light, and if it is below the light intensity threshold, it means that the stray light is weak, which thus does not degrade the clarity of the imaging.

[0059] Step **S20**, gluing and fixing the first polarization converter according to determined gluing position of the first polarization converter. After the position is determined and the optical adhesive on the first polarization converter is cured by air drying or ultraviolet drying, the fixation of the first polarization converter is completed. In addition, it should be noted that if the first polarization converter is provided on the light-incident surface of the imaging lens, then the second polarization converter may be set on the light-emergent surface of the imaging lens, and when the gluing position of the first polarization converter and the second polarization converter is adjusted, it is possible to simultaneously rotate the first polarization converter and the second polarization converter and find the best position for reducing the stray light between the two, followed by curing.

[0060] The embodiment of the assembling method for the imaging module of the present disclosure may refer to each embodiment of the above-mentioned imaging module, and will not be repeated herein.

[0061] The present disclosure also provides a head mount display which comprises a housing and the above imaging module, and the imaging module is provided within the housing. The housing provides a mounting space to support the imaging module, and the imaging module is provided

within the housing so as to prevent water vapor or dust from the external environment from falling into the interior of the imaging module.

[0062] The embodiment of the head mount display in the present disclosure may refer to each embodiment of the above-mentioned imaging module, and will not be repeated herein.

[0063] In the above embodiment, there are at least two cases where the imaging lens is provided, the first case being that the imaging lens is provided on the light-emergent surface of the display screen. In this way, the light directly enters the imaging lens after being emitted by the display screen to avoid the propagation of the light in the atmosphere, so as to reduce the optical medium through which the light passes, thereby reducing the reflection of the light and reducing the absorption of the light by the optical medium.

[0064] Besides, the second case is that the imaging lens is spaced apart from the display screen. In this way, it is possible to expand the propagation distance of the light, increase the optical path, and enable the light to have a sufficient catadioptric path, thereby enabling the light to be sufficiently enlarged and analyzed for imaging.

[0065] Table 1 lists the specific parameters of one embodiment of the imaging module and gives the corresponding coefficients for calculating the optical surface.

TABLE-US-00002

TABLE 1	thickness/	radius	4th	6th	8th	spacing of	curvature	aspheric	aspheric
aspheric part	material	surface (mm)	(mm)	coefficient	coefficient	coefficient	human eye	//	12
infinite	///	third lens	EP6000	light-emergent	3.6	169	-1.25E-05	3.42E-08	-8.53E-10
surface	light-incident	0.1	-77.7	-2.07E-05	-5.97E-08	1.20E-10	surface	polarization	/
0.08	infinite	///	reflector	surface	light-incident	0	infinite	///	surface
infinite	///	polarization	surface	converter	light-incident	0	infinite	///	surface
light-emergent	12.0	infinite	///	surface	light-incident	0	-92.3	1.56E-06	7.02E-09
surface	first lens	PMMA	light-emergent	2.9	-92.3	1.56E-06	7.02E-09	-1.72E-11	surface
light-incident	0	infinite	///	surface	first	/	light-emergent	0.08	infinite
light-incident	0	infinite	///	surface	linear	/	light-emergent	0.08	infinite
incident	1.0	infinite	///	surface	display	BK7	light-emergent	0.5	infinite
incident	0	infinite	///	surface					

[0066] In addition, with respect to the above embodiment, FIGS. 5, 6 and 7 show graphs of the modulation transfer function (MTF) of the imaging module in the present embodiment at 450 nm, 540 nm, and 610 nm, respectively, wherein the MTF map is the relationship between the modulation index and the number of line-pairs per millimeter in the image, which is used to evaluate the ability to restore the details of the scene. It can be seen from the figure that at a spatial frequency of 20 of line-pairs per millimeter, the MTF value of the imaging module is higher than 0.40 at a wavelength of 450 nm, the MTF value of the imaging module is higher than 0.75 at a wavelength of 540 nm, and the MTF value of the imaging module is higher than 0.55 at a wavelength of 610 nm.

[0067] The above are only the preferred embodiments of the present disclosure, and are not intended to limit the patent scope of the present disclosure. Any equivalent structural transformations made by utilizing the specification of the present disclosure and the accompanying drawings under the concept of the present disclosure or directly/indirectly applying them in other related technical fields are included in the scope of patent protection of the present disclosure.

Claims

1. An imaging module, comprising: a display screen configured for emitting light in a light-emergent direction; an imaging lens provided in the light-emergent direction; and a first polarization converter provided on the imaging lens; wherein the lights emitted by the display screen in different fields of view comprises a chief light centrally located in the light, wherein the chief light passes through a central region of an exit pupil position.

2. The imaging module of claim 1, wherein the chief light emitted by the display screen has an incident angle to a surface of the first polarization converter less than or equal to 5° .
 3. The imaging module of claim 1, wherein the chief light comprises a central chief light emitted from a central field of view of the display screen and a marginal chief light emitted from a marginal field of view of the display screen, wherein the central chief light has a first central incident angle α_1 to the first polarization converter when the central chief light is emitted to the first polarization converter for the first time, satisfying $\alpha_1=0$; and wherein the marginal chief light has an incident angle β_1 to the first polarization converter when the marginal chief light is emitted to the first polarization converter for the first time, satisfying $0^{\circ}\leq\beta_1\leq5^{\circ}$.
 4. The imaging module of claim 1, wherein the imaging lens is provided with a light-incident surface to which the light is incident, and a light-emergent surface from which the light is emergent, and the first polarization converter is provided on the light-incident surface or on the light-emergent surface of the imaging lens.
 5. The imaging module of claim 34, wherein the imaging module further comprises a second polarization converter provided on the light-emergent surface of the imaging lens, the first polarization converter is provided on the light-incident surface of the imaging lens, and both the light-incident surface and the light-emergent surface of the imaging lens are flat surfaces; wherein the central chief light has an incident angle α_2 to the second polarization converter when the central chief light is emitted to the second polarization converter for the first time, satisfying $\alpha_2=0$; and an incident angle of the marginal chief light has an incident angle β_2 to the second polarization converter when the marginal chief light is emitted to the second polarization converter for the first time, satisfying $0^{\circ}\leq\beta_2\leq5^{\circ}$.
 6. The imaging module of claim 1, wherein the imaging lens comprises a first lens and a second lens which are sequentially provided along a light propagation direction, are made of the same material, and are glued to each other; the first polarization converter is provided on a light-incident surface of the first lens, and a second polarization converter is provided on a light-emergent surface of the second lens.
 7. The imaging module of claim 6, wherein the first polarization converter and the second polarization converter are both phase retarders, and the imaging module further comprises: a linear polarizer provided on a side of the first polarization converter facing away from the first lens; a beam-splitter provided between the first lens and the second lens, and a polarization reflector provided on a side of the second polarization converter facing away from the second lens.
 8. The imaging module of claim 7, wherein the imaging module further comprises a third polarization converter which is a phase retarder and is provided between the linear polarizer and the display screen.
 9. The imaging module of claim 6, wherein the imaging module further comprises a third lens which is a positive lens and is provided on a side of the imaging lens facing away from the display screen; and a direction perpendicular to a direction of an optical axis of the imaging module is defined as a height direction, the imaging module has a height of D_1 , and the third lens has a height of D_2 , satisfying: $D_2<D_1$.
 10. An assembling method for an imaging module of claim 1, wherein the first polarization converter is glued to the imaging lens, and the assembling method comprises: adjusting a gluing angle of the first polarization converter on the imaging lens so as to determine a gluing position of the first polarization converter when a stray light is at a low ebb; and gluing and fixing the first polarization converter according to the determined gluing position of the first polarization converter.
 11. A head mount display, comprising: a housing; and an imaging module of claim 1, provided within the housing.
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