

VIRTUAL REALITY HEAD-MOUNTED APPARATUS

TECHNICAL FIELD

This application relates to the technical field of virtual reality, and in particular, to a virtual reality head-mounted apparatus.

BACKGROUND

Virtual reality (VR) technology is a technology that comprehensively utilizes a computer graphics system and various control interfaces to generate an interactive three-dimensional interaction environment on a computer to provide users with immersive experience. In related art, a user may wear a VR head-mounted apparatus, such as VR glasses or a VR helmet, or another VR apparatus, to obtain corresponding VR experience.

However, due to unique characteristics of VR scenarios, technical solutions for traditional electronic devices such as mobile phones or PCs may not be applicable to VR scenarios. For example, to acquire an infrared image of an eye of a user wearing a VR apparatus, due to structural limitations within the VR apparatus, image acquisition conditions for conventional methods may be difficult to meet, resulting in difficulties to successfully complete the corresponding tasks such as biometric recognition, eye tracking, etc.

SUMMARY

In view of these limitations, this application provides a VR head-mounted apparatus, which can improve the acquisition accuracy for an infrared image of an eye of a user.

To achieve the aforementioned objective, this application provides the following technical solutions.

According to a first aspect of this application, a VR head-mounted apparatus is provided. The VR head-mounted apparatus includes:

an apparatus body, wherein the apparatus body includes a convex lens, a camera and a partial-reflection partial-transmission lens for reflecting infrared light. The partial-reflection partial-transmission lens is located on a side of the convex lens away from a user, and the camera is located between the convex lens and the partial-reflection partial-transmission lens. A lens surface of the partial-reflection partial-transmission lens may be disposed obliquely, such that an infrared image of an eye of the user is reflected obliquely to the camera.

Optionally, the partial-reflection partial-transmission lens has a high transmittance for

visible light and a low transmittance for infrared light.

Optionally, the partial-reflection partial-transmission lens includes an infrared dichroic mirror.

Optionally, the camera is located outside a display area of a VR display component in the VR head-mounted apparatus with respect to the convex lens.

Optionally, the partial-reflection partial-transmission lens has a plate shape, the lens surface of the partial-reflection partial-transmission lens is inclined obliquely downward, the camera is located at a bottom of the apparatus body, and a lens of the camera is disposed obliquely upward.

Optionally, the partial-reflection partial-transmission lens has a plate shape, the lens surface of the partial-reflection partial-transmission lens is inclined obliquely upward, the camera is located at a top of the apparatus body, and a lens of the camera is disposed obliquely downward.

Optionally, the apparatus body may include two convex lenses, the partial-reflection partial-transmission lens is provided for at least one of the two convex lenses. The partial-reflection partial-transmission lens has a plate shape, the lens surface of the partial-reflection partial-transmission lens is horizontally inclined towards the two convex lenses, and the camera is located between the two convex lenses.

Optionally, the apparatus body includes a baffle, and the baffle is located on a side of the convex lens away from the user and between the two convex lenses in the apparatus body. The partial-reflection partial-transmission lens is rectangular, two side edges of the partial-reflection partial-transmission lens in a horizontal direction abut against the baffle and an inner wall of the apparatus body respectively, and the camera is installed on a side surface of the baffle.

Optionally, the apparatus further includes:

an infrared light source provided in the apparatus body, the infrared light source being located on a side of the convex lens close to the user, and providing infrared light compensation for an eye of the user.

Optionally, the infrared light source is distributed at a periphery of at least one convex lens, and the corresponding partial-reflection partial-transmission lens located at a side of the at least one convex lens away from the user.

Optionally, an installation position of the infrared light source is within a coverage area of a circumscribed rectangle of the corresponding convex lens.

Optionally, the apparatus further includes:

an apparatus interface provided on the apparatus body, the apparatus interface being electrically connected to an electronic device installed in the apparatus body, the electronic device being used to play VR display content,

the camera and the infrared light source being connected to the apparatus interface through a data line. Upon receiving a switch control instruction transmitted by the electronic device through the apparatus interface and the data line, the camera and the infrared light source perform a state switching operation in response to the switch control instruction, and the camera also transmits an acquired infrared image to the electronic device through the apparatus interface and the data line.

As can be seen from the above technical solutions, in this application, a partial-reflection partial-transmission lens is provided in a VR head-mounted apparatus, and a lens surface of the partial-reflection partial-transmission lens is disposed obliquely. Without interfering with a user's viewing of VR display content, by obliquely reflecting an infrared image of an eye of the user, a deviation angle of a camera during the acquisition of the infrared image of the eye can be reduced, thus reducing the deformation and distortion of the infrared image of the eye, and helping to improve the acquisition accuracy for the infrared image of the eye.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a side cross-sectional view of a VR helmet provided by an exemplary embodiment of this application.

FIG. 2 is a 3-D structural diagram of a VR helmet provided by an exemplary embodiment of this application.

FIG. 3 is a 3-D structural diagram of another VR helmet provided by an exemplary embodiment of this application.

FIG. 4 is a 3-D structural diagram of yet another VR helmet provided by an exemplary embodiment of this application.

FIG. 5 is a side cross-sectional view of another VR helmet provided by an exemplary embodiment of this application.

FIG. 6 is a structural diagram of a VR helmet, observed from a wearer's direction, provided by an exemplary embodiment of this application.

FIG. 7 is a schematic diagram of a positional relationship between an infrared light source and a convex lens provided by an exemplary embodiment of this application.

FIG. 8 is a side cross-sectional view of yet another VR helmet provided by an exemplary

embodiment of this application.

DETAILED DESCRIPTION OF THE INVENTION

The following embodiments are provided, using a VR helmet as an example, to introduce the related structure of a VR head-mounted apparatus of this application.

FIG. 1 is a side cross-sectional view of a VR helmet provided by an exemplary embodiment of this application. As shown in FIG. 1, the VR helmet may include: an apparatus body 1. The apparatus body 1 may include a convex lens 2 and a VR playing component 5. Further, the apparatus body 1 may further include a partial-reflection partial-transmission lens 3 for reflecting infrared light. The partial-reflection partial-transmission lens 3 is located on a side of the convex lens 2 away from a user (i.e., the partial-reflection partial-transmission lens 3 is located between the convex lens 2 and the VR playing component 5). Since the partial-reflection partial-transmission lens 3 has a high transmittance for visible light (relative to infrared light) and a low transmittance for infrared light (relative to visible light), VR display content played by the VR playing component 5 may, in a form of visible light S1, go through the partial-reflection partial-transmission lens 3 almost unaffected, and an eye 6 of the user receives the visible light S1 to view the VR display content. Infrared light S2 emitted from the eye 6 of the user is mostly, if not completely, reflected by the partial-reflection partial-transmission lens 3. The reflected infrared light S2' is acquired by a camera 4 located between the convex lens 2 and the partial-reflection partial-transmission lens 3, and the reflected infrared light S2' may form an infrared image of the eye 6, so as to achieve functions such as eye tracking and iris recognition. The camera 4 may be an infrared radiation (IR) camera or a red-green-blue (RGB)-IR integrated camera, which is not limited in this application. The camera 4 may include a variable-focus functional component that enables the camera 4 to achieve auto-focusing during image acquisition, thereby performing an acquisition operation on an infrared image of the eye 6 more quickly and accurately.

In this embodiment, the partial-reflection partial-transmission lens 3 for reflecting infrared light refers to a lens having a low transmittance for an infrared spectrum and a high transmittance for other spectra (e.g., visible light). By blocking most, if not all, of light in the low-transmittance infrared spectrum, the partial-reflection partial-transmission lens 3 reflects light in the infrared spectrum (i.e., “partial-reflection”). Meanwhile, most, if not all, of light in other spectra such as high-transmittance visible light can be transmitted through the

partial-reflection partial-transmission lens 3, minimizing the impact of the partial-reflection partial-transmission lens 3 on light in other spectra such as visible light (i.e., “partial-transmission”).

For example, the aforementioned partial-reflection partial-transmission lens 3 for reflecting infrared light may be an infrared dichroic mirror, such that a visible spectrum may be almost completely transmitted and an infrared spectrum may be almost completely reflected. Specifically, in one case, an infrared reflective film such as a TiO₂-Ag-TiO₂ infrared reflective film or a ZnS-Ag-ZnS infrared reflective film may be coated on a surface of an optical lens of high light transmittance for visible light (the visible spectrum may be almost completely transmitted), thereby forming the infrared dichroic mirror. In another example, a lens may be entirely made of the aforementioned infrared reflective film or a similar preparation material to form the infrared dichroic mirror.

More specifically, a lens surface 30 of the partial-reflection partial-transmission lens 3 is disposed obliquely, and positions of the partial-reflection partial-transmission lens 3 and the camera 4 may be arranged, such that the lens surface 30 of the partial-reflection partial-transmission lens 3 can obliquely reflect the infrared light S2 corresponding to the infrared image of the eye 6 towards the camera 4 to form the reflected infrared light S2'. Then, assuming that an angle α between the camera 4 and the infrared light S2 is maintained, and since the lens surface 30 of the partial-reflection partial-transmission lens 3 is disposed obliquely, the infrared light S2 is reflected toward the camera 4 to form the reflected infrared light S2', such that an angle β between the camera 4 and the reflected infrared light S2' is inevitably smaller than the aforementioned angle α . That reduces the possible deformation and distortion of the infrared image of an eye acquired by the camera 4, which helps to improve the acquisition accuracy for the infrared image of the eye 6, and to further improve the accuracy and precision of subsequent processing such as iris recognition and eye tracking.

In an actual case, inclination angles of the partial-reflection partial-transmission lens 3 and the camera 4 may be determined according to an internal space of the apparatus body 1. For example, the inclination angle of the partial-reflection partial-transmission lens 3 may be 45°, and a pointing direction of a lens of the camera 4 may be perpendicular or substantially perpendicular to the partial-reflection partial-transmission lens 3, which is not limited in this application.

Additionally, since the camera 4 is located between the convex lens 2 and the VR playing component 5, that is, an installation position of the camera 4 is located on a propagation line of the visible light S1, the installation position of the camera 4 may be

properly limited to avoid blocking the visible light S1. For example, as shown in FIG. 1, the camera 4 may be located, to the fullest extent possible, further away from a display area (for example, the display area may be indicated by an upper boundary T1 and a lower boundary T2 shown in FIG. 1) of the VR playing component 5 (i.e., a VR display component in the VR head-mounted apparatus) with respect to the convex lens 2.

When the relative positional relationship among the convex lens 2, the partial-reflection partial-transmission lens 3, the camera 4, and the VR playing component 5 remains unchanged, the partial-reflection partial-transmission lens 3 and the camera 4 may have various installation modes in the VR helmet, which will be described in the following examples.

In one embodiment, as shown in FIG. 2, when the partial-reflection partial-transmission lens 3 has a plate shape, the lens surface of the partial-reflection partial-transmission lens 3 may be inclined obliquely downward. For example, within a space between the convex lens 2 and the VR playing component 5, the partial-reflection partial-transmission lens 3 may have its upper edge abut against a top inner side of the space, and its lower edge abut against a bottom outer side of the space. The camera 4 may be located at a bottom of the apparatus body 1, and the lens of the camera 4 may be disposed obliquely upward to acquire the reflected infrared light S2' reflected by the partial-reflection partial-transmission lens 3. Although in a vertical direction, in order to avoid blocking the visible light S1, the camera 4 has to be located outside the aforementioned display area and cannot be at the same height as the eye 6, in a horizontal direction (a direction perpendicular to the paper in FIG. 1), a horizontal angle between the lens of the camera 4 and the infrared light S2 (or reflected infrared light S2') can be reduced, if not eliminated. For example, as shown in FIG. 2, since the eye 6 of the user is usually located at the middle of the convex lens 2 in the horizontal direction, the camera 4 may be located at the middle of the convex lens 2 in the horizontal direction, thereby reducing the probability that an infrared image of an eye is deformed or distorted.

In another embodiment, as shown in FIG. 3, when the partial-reflection partial-transmission lens 3 has a plate shape, the lens surface of the partial-reflection partial-transmission lens 3 may be inclined obliquely upward. For example, within a space between the convex lens 2 and the VR playing component 5, the partial-reflection partial-transmission lens 3 may have its upper edge abut against a top outer side of the space, and its lower edge abut against a bottom inner side of the space. The camera 4 is located at a top of the apparatus body 1, and the lens of the camera 4 may be disposed obliquely

downward to acquire the reflected infrared light S2' reflected by the partial-reflection partial-transmission lens 3. Then, similarly to the embodiment shown in FIG. 2, the camera 4 may also be located at the middle of the convex lens 2 in the horizontal direction to reduce, if not eliminate, the horizontal angle with the reflected infrared light S2', thereby reducing the probability that an infrared image of an eye is deformed or distorted.

In yet another embodiment, as shown in FIG. 4, when the apparatus body 1 includes two convex lenses 2 (corresponding to two eyes of the user respectively), the partial-reflection partial-transmission lens 3 may be provided for at least one convex lens 2 for performing infrared image reflection and acquisition on the corresponding eye of the user. For example, in FIG. 4, the partial-reflection partial-transmission lens 3 is provided only for a right convex lens 2 corresponding to a right eye of the user, and not for a left convex lens 2 corresponding to a left eye of the user. When the partial-reflection partial-transmission lens 3 has a plate shape, the lens surface of the partial-reflection partial-transmission lens 3 may be inclined horizontally towards the two convex lenses 2, and the camera 4 is located between the two convex lenses 2. For example, in FIG. 4, the partial-reflection partial-transmission lens 3 is provided for the right eye of the user. Within a space between the convex lens 2 and the VR playing component 5, the partial-reflection partial-transmission lens 3 may have its right side abut against a right interior of the space, and its left side abut against a left exterior of the space. That is, the lens surface of the partial-reflection partial-transmission lens 3 is inclined leftward, and the lens of the camera 4 is disposed in a left-to-right orientation to acquire the reflected infrared light S2' from the partial-reflection partial-transmission lens 3.

More specifically, the apparatus body 1 may include a baffle 7. The baffle 7 is located on a side of the convex lens 2 away from the user, and located between the two convex lenses 2 in the apparatus body 1. In order to adapt to a cuboid space inside the apparatus body 1, the partial-reflection partial-transmission lens 3 may be rectangular. To install the partial-reflection partial-transmission lens 3, two side edges of the partial-reflection partial-transmission lens 3 in the horizontal direction may abut against the baffle 7 and an inner wall of the apparatus body 1 respectively. The camera 4 may be installed on a side surface of the baffle 7 and face the lens surface of the partial-reflection partial-transmission lens 3.

In the aforementioned embodiment of this application, since the VR helmet needs to provide the user with an immersive VR scenario and user experience, the entrance of external light should be minimized. Therefore it may be difficult to satisfy the image acquisition condition of the camera 4 for the eye since light conditions inside the apparatus body 1 are

poor after the user wears the VR helmet. To address this issue, this application further proposes the following technical solutions based on the aforementioned embodiments.

The VR helmet of this application, as shown in FIG. 5, may further include an infrared light source 8 provided in the apparatus body 1. The infrared light source 8 is distributed at a periphery of at least one convex lens 2, and provides infrared light compensation (the infrared light source 8 emits infrared light such as R1 and R2 to the eye 6, as shown in FIG. 5) on an eye 6 of the user corresponding to the at least one convex lens 2. As shown in FIG. 6, the VR helmet is usually configured with two convex lenses 2 corresponding to the eyes of a user. The infrared light source 8 may be distributed at a periphery of one single convex lens 2. For example, the infrared light source may be distributed at a periphery of a right convex lens 2 in FIG. 6 to provide infrared light compensation on the right eye of the user, and not distributed at a periphery of a left convex lens 2. Certainly, in other embodiments, an infrared light source 8 may be simultaneously disposed at peripheries of the two convex lenses 2 for infrared light compensation. Detail implementation is not limited in this application.

In fact, in the VR helmet, positions of the infrared light source 8, the camera 4, and the partial-reflection partial-transmission lens 3 are related with each other. For example, as shown in FIG. 6, to perform eye tracking, iris recognition, etc. on the right eye of the user, at least one infrared light source 8 may be disposed at the periphery of the right convex lens 2. Moreover, the partial-reflection partial-transmission lens 3 and the camera 4 may be provided at a side of the right convex lens 2 away from the user to achieve corresponding infrared image acquisition. Similarly, to perform eye tracking, iris recognition, etc. on both eyes of the user, infrared light sources 8 may be disposed at the peripheries of the two convex lenses 2 simultaneously, and the partial-reflection partial-transmission lens 3 and the camera 4 may be provided at a side of each convex lens 2 away from the user to achieve corresponding infrared image acquisition.

Although the embodiment shown in FIG. 6 has four infrared light sources 8 distributed at a periphery of the right convex lens 2, it is only used as an example here. In fact, in the VR helmet of this application, one or more infrared light sources 8 may be distributed at a periphery of each convex lens. The number of infrared light sources 8 is not limited in this application. When there exist multiple infrared light sources 8 (e.g., when four infrared light sources 8 are distributed at a periphery of the right convex lens 2 as shown in FIG. 6), these infrared light sources 8 may be, to the fullest extent possible, uniformly distributed to provide uniform light compensation for the eye 6.

Additionally, when the apparatus body 1 includes the convex lens 2, an external size of

the apparatus body 1 is related to the space occupation of the convex lens 2. For example, as shown in FIG. 7, assuming the convex lens 2 has a length of L in a horizontal direction (i.e., x-axis direction in FIG. 7), and a length of H in a vertical direction (i.e., y-axis direction in FIG. 7, when the convex lens 2 is a circle, L and H are equal to a diameter length of the circle). Then, the space occupation of the convex lens 2 for the apparatus body 1 is related to values of L and H . That is, the apparatus body 1 may have a length of at least L in the horizontal direction, and a length of at least H in the vertical direction. In fact, when the apparatus body 1 has a substantially rectangular parallelepiped shape, an external size of the apparatus body 1 required by the convex lens 2 is substantially the same as the external size of the apparatus body 1 required by a circumscribed rectangle (as shown in FIG. 7, the circumscribed rectangle has a horizontal width of L and a vertical height of H) of the convex lens 2.

In one embodiment, as shown in FIG. 7, when an installation position of the infrared light source 8 is located within a coverage area of the circumscribed rectangle of the convex lens 2, since the infrared light source 8 needs to avoid blocking the convex lens 2, the infrared light source 8 should not be located within the convex lens 2 (e.g., point A), but should be located within a shaded area (e.g., point B) shown in FIG. 7. In this case, a space needed by the apparatus body 1 that has the infrared light source 8 may overlap with the circumscribed rectangle (or the convex lens 2 itself), so that the infrared light source 8 does not require additional space from the apparatus body 1. That helps to control or even reduce the size of the apparatus body 1 and the VR helmet, and prevent the VR helmet from being too bulky and cumbersome.

In another embodiment, as shown in FIG. 7, when the infrared light source 8 is located at point C, an overall height of a combination of the infrared light source 8 and the convex lens 2 in the vertical direction increases from H to H_1 . That is, a space occupation requirement for the apparatus body 1 in the vertical direction increases from H to H_1 , and the VR helmet becomes thicker. Similarly, when the infrared light source 8 is located at point D, an overall width of a combination of the infrared light source 8 and the convex lens 2 in the horizontal direction increases from L to L_1 . That is, a space occupation requirement for the apparatus body 1 in the horizontal direction increases from L to L_1 , and the VR helmet becomes wider.

Therefore, to the fullest extent possible, the infrared light source 8 can be provided within the coverage area of the circumscribed rectangle of the corresponding convex lens 2 to avoid increasing the space occupation requirement for the apparatus body 1, and to help control the space occupied by the VR helmet.

FIG. 8 is a side cross-sectional view of another VR helmet provided by an exemplary embodiment of this application. As shown in FIG. 8, the VR helmet may be a split-style VR head-mounted apparatus, and the apparatus body 1 of the VR helmet may comprise an apparatus interface 9, so that the apparatus interface 9 may be electrically connected to an electronic device such as a mobile phone or a tablet installed in the apparatus body 1. By using a processor or a graphics card chip, etc. for rendering, and using a screen component for content displaying, the electronic device may work as the VR playing component 5 in the apparatus body 1.

Further, the camera 4 and the infrared light source 8 in the apparatus body 1 may be connected to the apparatus interface 9 through a data line 10, so that when the electronic device connected to the apparatus interface 9 issues a switch control instruction, the camera 4 and the infrared light source 8 may receive the switch control instruction through the apparatus interface 9 and the data line 10 to perform a state switching operation in response to the switch control instruction. In other words, based on the user control to the electronic device or an application program running on the electronic device, the electronic device may send a switch control instruction to the camera 4 and the infrared light source 8, thereby controlling the infrared light source 8 to provide infrared light compensation on the eye 6 and controlling the camera 4 to perform infrared image acquisition on the eye 6. That improves the controllability of infrared light compensation and infrared image acquisition.

The switch control instruction may be sent to the camera 4 and the infrared light source 8 simultaneously. Alternatively, the switch control instruction may also be separately sent to the camera 4 or the infrared light source 8. For example, the instruction may separately control the camera 4 to perform infrared image acquisition, and separately control the infrared light source 8 to provide infrared light compensation in case of poor light condition.

Additionally, after the camera 4 completes the infrared image acquisition, if the VR helmet comprises a processing module, the acquired infrared image may be transmitted to the processing module for processing. Alternatively, the camera 4 may transmit, through the apparatus interface 9 and the data line 10, the acquired infrared image to the aforementioned electronic device for processing by the electronic device.

Certainly, the VR helmet of this application may include other forms of VR head-mounted apparatuses other than the split-style VR head-mounted apparatus paired with an electronic device such as a mobile phone. For example, for the split-style VR head-mounted apparatus, the VR helmet may be paired with a PC host, a game console or another external apparatus, so the VR playing component 5 may be a display component built

into the VR helmet, and the external apparatus is used for rendering VR display content. For another example, the VR helmet may be an integrated VR head-mounted apparatus. That is, the VR helmet may be able to play VR display content without resorting to any external apparatus. The VR playing component 5 is built-in in the VR helmet, and may have playing functions such as rendering and displaying of VR display content.

It should also be noted that the terms “include”, “comprise” and any other variants mean to cover the non-exclusive inclusion. Thereby, the process, method, article, or device which include a series of elements not only include those elements, but also include other elements which are not clearly listed, or include the inherent elements of the process, method, article and device. Without further limitation, the element defined by a phrase “include one.....” does not exclude other same elements in the process, method, article or device which include the element.

Reference are made in detail to exemplary embodiments, examples of which are illustrated in the accompanying drawings. The above description refers to the accompanying drawings in which the same numbers in different drawings represent the same or similar elements unless otherwise represented. The implementations set forth in the above description of exemplary embodiments do not represent all implementations consistent with this application. Instead, they are merely examples of apparatuses and methods consistent with aspects related to this application as recited in the appended claims.

The terms used in this application are merely for the purpose of describing specific embodiments, and are not intended to limit this application. The terms “a”, “said” and “the” of singular forms used in this application and the appended claims are also intended to include plural forms, unless otherwise specified in the context clearly. It should also be understood that, the term “and/or” used herein indicates and includes any or all possible combinations of one or more associated listed items.

It should be understood that although the terms such as first, second, and third may be used herein to describe various information, such information should not be limited to these terms. These terms are merely used for distinguishing information of the same type from each other. For example, within the scope of this application, first information may also be referred to as second information, and similarly, second information may also be referred to as first information. Depending on the context, the term “if” as used herein may be interpreted as “when ...” or “upon ...” or “in response to determining.”

The above descriptions are merely exemplary embodiments of this application, but are not intended to limit this application. Any modification, equivalent replacement, or

improvement made without departing from the spirit and principle of this application should fall within the protection scope of this application.

CLAIMS

1. A virtual reality (VR) head-mounted apparatus, comprising:

an apparatus body, the apparatus body comprising a convex lens, a camera and a partial-reflection partial-transmission lens for reflecting infrared light, the camera located between the convex lens and the partial-reflection partial-transmission lens, and a lens surface of the partial-reflection partial-transmission lens disposed obliquely, such that an infrared image of an eye of a user is obliquely reflected to the camera; and

one or more infrared light sources provided in the apparatus body, the one or more infrared light sources located on a side of the convex lens close to the user, and providing infrared light compensation for an eye of the user,

wherein the one or more infrared light sources are distributed at a periphery of the convex lens, and the partial-reflection partial-transmission lens is located on a side of the convex lens away from the user within a space adjacent the convex lens and a VR display component, the partial-reflection partial-transmission lens has an upper edge abut against a top inner side of the space and a lower edge abut against a bottom outer side of the space, or an upper edge abut against a top outer side of the space and a lower edge abut against a bottom inner side of the space, and

wherein all of the one or more infrared light sources are located within a coverage area of a circumscribed rectangle of the convex lens and outside the convex lens when viewed along a direction parallel with an optical axis of the convex lens, and the circumscribed rectangle has a same horizontal width and a same vertical height as those of the convex lens.

2. The apparatus according to claim 1, wherein the partial-reflection partial-transmission lens has a high transmittance for visible light and a low transmittance for infrared light.

3. The apparatus according to claim 1, wherein the partial-reflection partial-transmission lens comprises an infrared dichroic mirror.

4. The apparatus according to claim 1, wherein the camera is located outside a display area of the VR display component in the VR head-mounted apparatus with respect to the convex lens.

5. The apparatus according to claim 1, wherein the partial-reflection partial-transmission lens has a plate shape, the lens surface of the partial-reflection partial-transmission lens is inclined obliquely downward, the camera is located at a bottom of the apparatus body, and a lens of the camera is disposed obliquely upward.

6. The apparatus according to claim 1, wherein the partial-reflection partial-transmission lens has a plate shape, the lens surface of the partial-reflection partial-transmission lens is inclined obliquely upward, the camera is located at a top of the apparatus body, and a lens of the camera is disposed obliquely downward.

7. The apparatus according to claim 1, wherein the convex lens is a first convex lens, and the apparatus body further comprises a second convex lens, the partial-reflection partial-transmission lens is provided for at least one of the first and the second convex lenses, and the partial-reflection partial-transmission lens has a plate shape, the lens surface of the partial-reflection partial-transmission lens is horizontally inclined towards the first and the second convex lenses, and the camera is located between the first and the second convex lenses.

8. The apparatus according to claim 7, wherein the apparatus body comprises a baffle, the baffle is located on a side of the convex lenses away from the user, and located between the first and the second convex lenses in the apparatus body; the partial-reflection partial-transmission lens is rectangular, two side edges of the partial-reflection partial-transmission lens in a horizontal direction abut against the baffle and an inner wall of the apparatus body respectively; and the camera is installed on a side surface of the baffle.

9. The apparatus according to claim 1, further comprising:

an apparatus interface provided on the apparatus body, the apparatus interface electrically connected to an electronic device installed in the apparatus body, the electronic device configured to play VR display content,

the camera and the infrared light source connected to the apparatus interface through a data line, wherein the camera is configured to, upon receiving a switch control instruction transmitted by the electronic device through the apparatus interface and the data line, transmit an

acquired infrared image to the electronic device through the apparatus interface and the data line.