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Head-mounted display device and adjustment module

Abstract

A head-mounted display device and an adjustment module are provided. The head-mounted display device includes a body and two adjustment modules. The two adjustment modules are configured to be assembled to two zoom lens groups of the body. Each of the adjustment modules includes a base, a sliding block, a first shape memory alloy (SMA) element, a first recovery element, a braking element, a second SMA element, and a second recovery element. The first SMA element is connected between the base and an actuating end of the sliding block and is configured to actuate the sliding block so that a transmission end of the sliding block drives the zoom lens group to zoom. The first recovery element is connected between the base and the actuating end and is configured to keep the sliding block at an original position when the first SMA element is in a power-off state. The braking element is engaged with a braking end of the sliding block when the braking element is in a braking position. The braking element is separated from the braking end when the braking element is in a movable position. The second SMA element is connected between the base and the braking element and is configured to actuate the braking element to move between the braking position and the movable position. The second recovery element is connected between the base and the braking element and is configured to keep the braking element at the braking position or the movable position when the second SMA element is in the power-off state.

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Background/Summary

BACKGROUND

Technical Field

(1) The invention relates to a head-mounted display device and an adjustment module, and in particular, relates to a head-mounted display device capable of auto-zooming and an adjustment module.

Description of Related Art

(2) At present, with the rapid advancement of technology, the types and functions of head-mounted display devices are increasingly diversified. Taking a head-mounted display device of the eye mask type as an example, when a user wears this type of device, the gyroscope and position tracker

inside the head-mounted display device will track the user's movement status to project corresponding scene images, providing the user with an experience as if he/she is in a virtual world.
(3) When using the head-mounted display device, since each user has a different degree of myopia, two zoom lens groups can be provided in the head-mounted display device to suit different users, so that each user can enjoy the best experience. In a head-mounted display device currently available in the market, the zoom lens groups are mainly zoomed manually. However, a user may not be able to obtain the best zooming effect through manual operation.

SUMMARY

(4) The invention provides a head-mounted display device and an adjustment module capable of providing a motorized zooming function.
(5) The invention provides a head-mounted display device including a body and two adjustment modules. The body has two zoom lens groups corresponding to both eyes. The two adjustment modules are configured to be assembled to the two zoom lens groups. Each of the adjustment modules includes a base, a sliding block, a first shape memory alloy (SMA) element, a first recovery element, a braking element, a second SMA element, and a second recovery element. The sliding block has an actuating end, a braking end, and a transmission end. The first SMA element is connected between the base and the actuating end and is configured to actuate the sliding block so that the transmission end drives the corresponding zoom lens group to zoom. The first recovery element is connected between the base and the actuating end and is configured to keep the sliding block at an original position when the first SMA element is in a power-off state. The braking element is engaged with the braking end when the braking element is in a braking position. The braking element is separated from the braking end when the braking element is in a movable position. The second SMA element is connected between the base and the braking element and is configured to actuate the braking element to move between the braking position and the movable position. The second recovery element is connected between the base and the braking element and is configured to keep the braking element at the braking position or the movable position when the second SMA element is in the power-off state.
(6) The invention further provides an adjustment module configured to be assembled to a zoom lens group of the head-mounted display device. The adjustment module includes a base, a sliding block, a first shape memory alloy (SMA) element, a first recovery element, a braking element, a second SMA element, and a second recovery element. The sliding block has an actuating end, a braking end, and a transmission end. The first SMA element is connected between the base and the actuating end and is configured to actuate the sliding block so that the transmission end drives the zoom lens group to zoom. The first recovery element is connected between the base and the actuating end and is configured to keep the sliding block at an original position when the first SMA element is in a power-off state. The braking element is engaged with the braking end when the braking element is in a braking position. The braking element is separated from the braking end when the braking element is in a movable position. The second SMA element is connected between the base and the braking element and is configured to actuate the braking element to move between the braking position and the movable position. The second recovery element is connected between the base and the braking element and is configured to keep the braking element at the braking position or the movable position when the second SMA element is in the power-off state.
(7) To sum up, in the head-mounted display device and the adjustment module provided by the invention, the first SMA element can drive the zoom lens group to zoom, the second SMA element can drive the braking element to allow zooming or prohibit zooming, and motorized zooming is thereby achieved.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

(1) FIG. **1** is a schematic view of a head-mounted display device according to an embodiment of the invention.

(2) FIG. **2** is a schematic view of some elements of an adjustment module of the head-mounted display device of FIG. **1**.

(3) FIG. **3** is a schematic view of some other elements of the adjustment module of the head-mounted display device of FIG. **1**.

(4) FIG. **4** is a cross-sectional schematic view illustrating operation of the adjustment module and a zoom lens group of the head-mounted display device of FIG. **1**.

(5) FIG. **5** is a schematic view of another section of FIG. **4**.

(6) FIG. **6** is another cross-sectional schematic view illustrating operation of the adjustment module and the zoom lens group of the head-mounted display device of FIG. **1**.

(7) FIG. **7** is a schematic view of another section of FIG. **6**.

(8) FIG. **8** to FIG. **10** are schematic views of three states of the adjustment module of the head-mounted display device of FIG. **1**.

DESCRIPTION OF THE EMBODIMENTS

(9) FIG. **1** is a schematic view of a head-mounted display device according to an embodiment of the invention. With reference to FIG. **1**, a head-mounted display device **100** provided by this embodiment includes a body **110** and two adjustment modules **120**. The body **110** has a zoom lens group **112** and a zoom lens group **114** corresponding to both eyes. The two adjustment modules **120** are configured to be assembled to the zoom lens group **112** and the zoom lens group **114**. That is, one adjustment module **120** is assembled to the zoom lens group **112**, and the other adjustment module **120** is assembled to the zoom lens group **114**. The zoom lens group **112** and the zoom lens group **114** can perform zooming individually and independently.

(10) FIG. **2** is a schematic view of some elements of the adjustment module **120** of the head-mounted display device **100** of FIG. **1**. FIG. **3** is a schematic view of some other elements of the adjustment module **120** of the head-mounted display device **100** of FIG. **1**. With reference to FIG. **2** and FIG. **3**, in this embodiment, each of the adjustment modules **120** includes a base **122**, a sliding block **124**, a shape memory alloy (SMA) element **126**A, a first recovery element **126**B, a braking element **128**, a second SMA element **126**C, and a second recovery element **126**D. In FIG. **2**, the elements located in front of the base **122** are omitted, and the base **122** is shown in a see-through state to clearly show the elements behind the base **122**. In FIG. **3**, the base **122** is shown in a non-see-through state, so that the elements behind the base **122** cannot be seen.

(11) With reference to FIG. **1** and FIG. **2**, the sliding block **124** has an actuating end **124**A, a braking end **124**C, and a transmission end **124**B. The first SMA element **126**A is connected between the base **122** and the actuating end **124**A and is configured to actuate the sliding block **124** so that the transmission end **124**B drives the corresponding zoom lens group **112** or the zoom lens group **114** to zoom. The temperature of the first SMA element **126**A may increase by electrifying it, and a length of the first SMA element **126**A may also change accordingly, thus driving the sliding block **124** to move. The first recovery element **126**B is connected between the base **122** and the actuating end **124**A and is configured to keep the sliding block **124** at an original position when the first SMA element **126**A is in a power-off state. Herein, the specific position of the original position is not limited. As long as the first SMA element **126**A is in the power-off state, the sliding block **124** is forced by the first SMA element **126**A and the first recovery element **126**B simultaneously to reach the force balance position, it is the original position. The original position may be affected and change by various parameters such as materials and sizes of the first recovery element **126**B and the first SMA element **126**A. Besides, keeping the sliding block **124** at the original position by the first recovery element **126**B means that the sliding block **124** has a tendency to move towards the original position and stop at the original position. However, if it is affected by other external

forces, such as the action of an actuating element to be mentioned in the following paragraphs, the sliding block **124** may not reach the original position.

(12) With reference to FIG. **1** and FIG. **3**, the braking element **128** is engaged with the braking end **124**C when the braking element **128** is in a braking position. The braking element **128** in FIG. **3** is at the braking position and is engaged with the braking end **124**C. The braking element **128** is separated from the braking end **124**C when it is in a movable position, such as the positions of the braking element **128** in FIG. **7** and FIG. **9**. In fact, as long as the braking element **128** is separated from the braking end **124**C, it is a movable position. The second SMA element **126**C is connected between the base **122** and the braking element **128** and is configured to actuate the braking element **128** to move between the braking position and the movable position. The second recovery element **126**D is connected between the base **122** and the braking element **128** and is configured to keep the braking element **128** at the braking position or the movable position when the second SMA element **126**C is in the power-off state.

(13) For instance, in this embodiment, the second SMA element **126**C may contract after being electrified and heated, so that the actuated braking element **128** is located at the movable position, and the second recovery element **126**D may keep the braking element **128** at the braking position when the second SMA element **126**C is in the power-off state. Keeping the braking element **128** at the braking position by the second recovery element **126**D means that the braking element **128** has a tendency to move towards the braking position and stop at the braking position. However, if it is affected by other external forces, the braking element **128** may not reach the movable position.

(14) In the head-mounted display device and the adjustment modules provided by this embodiment, the zoom lens group **112** and the zoom lens group **114** may individually and independently perform zooming via the matching adjustment modules **120**. Therefore, if a user is short-sighted, the zoom lens group **112** and the zoom lens group **114** may be zoomed to obtain clear images. Moreover, even if the degrees of myopia of both eyes of the user are different, the zoom lens group **112** and the zoom lens group **114** may be individually zoomed so that both eyes can obtain clear images. In addition, because the first SMA element **126**A is used to drive the sliding block **124** to zoom, the zooming may be performed in a motorized zooming manner, and improved precision is thereby provided. Besides, because the second SMA element **126**C is used to drive the braking element **128** to allow zooming or prohibit zooming, both the zoom lens group **112** and the zoom lens group **114** may be kept in a zoom state suitable for the user.

(15) FIG. **4** is a cross-sectional schematic view illustrating operation of the adjustment module and a zoom lens group of the head-mounted display device of FIG. **1**. FIG. **5** is a schematic view of another section of FIG. **4**. With reference to FIG. **4** and FIG. **5**, in this embodiment, the first SMA element **126**A and the first recovery element **126**B are located at two opposite sides of the actuating end **124**A. Certainly, the first SMA element **126**A and the first recovery element **126**B may also be connected to the same side of the actuating end **124**A or connected to other different orientations, which is not limited in the invention. In this embodiment, the transmission end **124**B is in the shape of a rack. Correspondingly, the exterior of a focus ring **112**A of the zoom lens group **112** is gear-shaped, so that the transmission end **124**B may be engaged with the focus ring **112**A of the zoom lens group **112** and rotate the focus ring **112**A.

(16) In this embodiment, the first SMA element **126**A contracts after being electrified and heated to drive the actuating end **124**A. However, in other embodiments, the first SMA element **126**A may also be designed to extend after being electrified and heated to push the actuating end **124**A.

(17) In the state shown in FIG. **4** and FIG. **5**, the braking element **128** is at the braking position and is engaged with the braking end **124**C of the sliding block **124**. In this way, the sliding block **124** cannot move, and the focus ring **112**A of the zoom lens group **112** cannot rotate, so that the position of a lens **112**B corresponding to the focus ring **112**A is fixed.

(18) FIG. **6** is another cross-sectional schematic view illustrating operation of the adjustment module and the zoom lens group of the head-mounted display device of FIG. **1**. FIG. **7** is a

schematic view of another section of FIG. **6**. In the state shown in FIG. **6** and FIG. **7**, the braking element **128** is located at the movable position and is separated from the sliding block **124**. In this way, the sliding block **124** can move and the focus ring **112**A of the zoom lens group **112** can rotate, so that the lens **112**B corresponding to the focus ring **112**A may be moved, for example, may be moved upwards from the position shown in FIG. **5** to the position shown in FIG. **7**. In other embodiments, the sliding block **124** may also drive other lenses in the zoom lens group **112** to achieve the function of zooming.
(19) FIG. **8** to FIG. **10** are schematic views of three states of the adjustment module of the head-mounted display device of FIG. **1**. With reference to FIG. **8**, in this embodiment, the braking element **128** has a pivot end **128**A, a first protrusion **128**B, and a second protrusion **128**C. The braking element **128** is pivotally connected to the base **122** through the pivot end **128**A, that is, the braking element **128** can rotate relative to the base **122** with the pivot end **128**A as a rotation axis. The second SMA element **126**C is connected between the base **122** and the first protrusion **128**B. The second recovery element **126**D is connected between the base **122** and the second protrusion **128**C. In this embodiment, each of the second SMA element **126**C and the second recovery element **126**D is in the shape of a straight line, and the two bypass the first protrusion **128**B and the second protrusion **128**C respectively, but the invention is not limited thereto.
(20) Therefore, when the second SMA element **126**C contracts after being electrified and heated, the second SMA element **126**C may push the first protrusion **128**B to make the braking element **128** rotate in one direction, for example, rotate in a direction where it can be separated from the braking end **124**C. When the second recovery element **126**D contracts after being electrified and heated, the second recovery element **126**D may push the second protrusion **128**C to make the braking element **128** rotate in another direction, for example, rotate in a direction where it can be engaged with the braking end **124**C. In this embodiment, a material of the second recovery element **126**D is a SMA, but the invention is not limited thereto. In an embodiment that is not shown, a torsion spring may also be provided at the pivot end **128**A to replace or assist the second recovery element **126**D to provide torque to the braking element **128**, so that it rotates in the opposite direction when it is braked by the second SMA element **126**C.
(21) In this embodiment, the base **122** has a protrusion **122**A. The braking element **128** further includes a positioning groove **128**D. The protrusion **122**A is accommodated in the positioning groove **128**D, and the protrusion **122**A and the positioning groove **128**D can move relatively. The positioning groove **128**D has a first end **128**D**1**, a second end **128**D**2**, and a neck portion **128**D**3**, and the neck portion **128**D**3** is located between the first end **128**D**1** and the second end **128**D**2**. A width of the neck portion **128**D**3** is slightly less than a width of the protrusion **122**A. Therefore, after the protrusion **122**A passes through the neck portion **128**D**3**, it can stay stably at the first end **128**D**1** or the second end **128**D**2**.
(22) With reference to FIG. **5** and FIG. **8**, before operating, the braking element **128** is located at the braking position and is engaged with the braking end **124**C, so that the sliding block **124** cannot move, and that the position of the lens **112**B corresponding to the focus ring **112**A of the zoom lens group **112** is fixed. When the braking element **128** is at the braking position, the protrusion **122**A is located at the first end **128**D**1** of the positioning groove **128**D. When the protrusion **122**A is located at the first end **128**D**1** of the positioning groove **128**D, the neck portion **128**D**3** may engage the protrusion **122**A in the first end **128**D**1** of the positioning groove **128**D, so that the braking element **128** is positioned at the braking position.
(23) With reference to FIG. **7** and FIG. **9**, when the user inputs a zoom command, for example, the second SMA element **126**C is electrified and heated to contract, the second recovery element **126**D made of a general elastic material is elastically stretched under force or the second recovery element **126**D made of a SMA is in the power-off state, so that the second SMA element **126**C actuates the braking element **128** to rotate towards the movable position. That is, the second SMA element **126**C pushes the first protrusion **128**B to make the braking element **128** rotate in a

direction where it can be separated from the braking end **124**C. When the braking element **128** reaches the movable position, the protrusion **122**A reaches the second end **128**D**2** through the neck portion **128**D**3**. When the protrusion **122**A is located at the second end **128**D**2** of the positioning groove **128**D, the neck portion **128**D**3** may engage the protrusion **122**A in the second end **128**D**2** of the positioning groove **128**D, so that the braking element **128** is positioned at the movable position.
(24) In this embodiment, when the second recovery element **126**D is also a SMA, the width of the neck portion **128**D**3** is slightly less than the width of the protrusion **122**A. Therefore, after the protrusion **122**A passes through the neck portion **128**D**3**, it can stay stably at the first end **128**D**1** or the second end **128**D**2**. In other words, when the second SMA element **126**C and the second recovery element **126**D made of a SMA are powered off, the protrusion **122**A may stay stably at the first end **128**D**1** or the second end **128**D**2**, and in this way, power consumption is saved and the service life of the second SMA element **126**C and the second recovery element **126**D is extended.
(25) Next, with reference to FIG. **6**, the first SMA element **126**A is shortened by being electrified and heated, and then the sliding block **124** is driven away from the position shown in FIG. **5**. During the movement of the sliding block **124**, the focus ring **112**A of the zoom lens group **112** is also rotated, so that the lens **112**B corresponding to the focus ring **112**A is moved. The timing of stopping the movement of the sliding block **124** is determined, for example, by the user according to the clarity of the image viewed by the user. The user may also control the sliding block **124** to move forwards or backwards, so as to find the state where the clearest image can be seen. Alternatively, regarding the timing of stopping the movement of the sliding block **124**, the user may directly input the degree of myopia, and the head-mounted display device **100** directly controls the sliding block **124** to stop at a position corresponding to the degree of myopia inputted by the user. In this embodiment, each of the adjustment modules **120** may further include a position sensor **129** (shown in FIG. **7**) assembled to the base **122** for sensing a position of the sliding block **124**. Therefore, the head-mounted display device **100** may sense whether the sliding block **124** is moved to a position and stop it at the position. For instance, the position sensor **129** may be a variable resistor, an optical sensor, or a Hall sensor.
(26) With reference to FIG. **10**, when zooming is completed, for example, the second SMA element **126**C is powered off, the second recovery element **126**D made of a general elastic material contracts due to its elastic recovery force or the second recovery element **126**D made of a SMA contracts after being electrified and heated, the braking element **128** is actuated to rotate towards the braking position. That is, the second recovery element **126**D may push the second protrusion **128**C to rotate the braking element **128** towards the direction to be engaged with the braking end **124**C until the braking element **128** is engaged with the braking end **124**C. Herein, the sliding block **124** cannot move. Therefore, the position of the lens **112**B (shown in FIG. **5**) corresponding to the focus ring **112**A of the zoom lens group **112** is fixed, and the user can stably see a clear image. In other words, in this embodiment, at the braking position, the first SMA element **126**A and the second SMA element **126**C may be powered off, so that power consumption is saved, and the service life is prolonged.
(27) In an embodiment, the user directly inputs the degree of myopia, and the head-mounted display device **100** directly controls the movement of the sliding block **124**. If the position sensor **129** detects that the sliding block **124** reaches the target position, the second SMA element **126**C is powered off, so that the second recovery element **126**D actuates the braking element **128** to rotate towards the braking position, and the entire operation is completed.
(28) In view of the foregoing, in the head-mounted display device and the adjustment module provided by the invention, the user can electrically control the first SMA element to zoom the zoom lens group and can also electrically control the second SMA element to allow zooming or prohibit zooming. In this way, the convenience of use can be improved, and a precise zooming effect can also be obtained.

Claims

1. A head-mounted display device, comprising: a body having two zoom lens groups corresponding to both eyes; and two adjustment modules configured to be assembled to the two zoom lens groups, wherein each of the two adjustment modules comprises: a base; a sliding block having an actuating end, a braking end, and a transmission end; a first shape memory alloy element connected between the base and the actuating end and configured to actuate the sliding block so that the transmission end drives the corresponding zoom lens group of the two lens groups to zoom; a first recovery element connected between the base and the actuating end and configured to keep the sliding block at an original position when the first shape memory alloy element is in a power-off state; a braking element engaged with the braking end when the braking element is in a braking position and separated from the braking end when the braking element is in a movable position; a second shape memory alloy element connected between the base and the braking element and configured to actuate the braking element to move between the braking position and the movable position; and a second recovery element connected between the base and the braking element and configured to keep the braking element at the braking position or the movable position when the second shape memory alloy element is in the power-off state.
2. The head-mounted display device according to claim 1, wherein the first shape memory alloy element and the first recovery element are located at two opposite sides of the actuating end.
3. The head-mounted display device according to claim 1, wherein the transmission end is in the shape of a rack.
4. The head-mounted display device according to claim 1, wherein each of the two adjustment modules further comprises a position sensor assembled to the base for sensing a position of the sliding block.
5. The head-mounted display device according to claim 1, wherein the braking element has a pivot end, a first protrusion, and a second protrusion, the second shape memory alloy element is connected between the base and the first protrusion, the second recovery element is connected between the base and the second protrusion, the second shape memory alloy element contracts after being electrified and heated to actuate the braking element to rotate towards the movable position, and the second recovery element contracts to actuate the braking element to rotate towards the braking position after the second shape memory alloy element is powered off.
6. The head-mounted display device according to claim 1, wherein each of the second shape memory alloy element and the second recovery element is in the shape of a straight line.
7. The head-mounted display device according to claim 1, wherein a material of the second recovery element is a shape memory alloy.
8. The head-mounted display device according to claim 1, wherein the braking element has a positioning groove, the base has a protrusion, the protrusion is located at a first end of the positioning groove when the braking element is located at the braking position, the protrusion is located at a second end of the positioning groove when the braking element is located at the movable position, a neck portion of the positioning groove is located between the first end and the second end, and a width of the neck portion is slightly less than a width of the protrusion.
9. An adjustment module configured to be assembled to a zoom lens group of a head-mounted display device, the adjustment module comprising: a base; a sliding block having an actuating end, a braking end, and a transmission end; a first shape memory alloy element connected between the base and the actuating end and configured to actuate the sliding block so that the transmission end drives the zoom lens group to zoom; a first recovery element connected between the base and the actuating end and configured to keep the sliding block at an original position when the first shape memory alloy element is in a power-off state; a braking element engaged with the braking end when the braking element is in a braking position and separated from the braking end when the

braking element is in a movable position; a second shape memory alloy element connected between the base and the braking element and configured to actuate the braking element to move between the braking position and the movable position; and a second recovery element connected between the base and the braking element and configured to keep the braking element at the braking position or the movable position when the second shape memory alloy element is in the power-off state.

10. The adjustment module according to claim 9, wherein the first shape memory alloy element and the first recovery element are located at two opposite sides of the actuating end.

11. The adjustment module according to claim 9, wherein the transmission end is in the shape of a rack.

12. The adjustment module according to claim 9, further comprising a position sensor assembled to the base for sensing a position of the sliding block.

13. The adjustment module according to claim 9, wherein the braking element has a pivot end, a first protrusion, and a second protrusion, the second shape memory alloy element is connected between the base and the first protrusion, the second recovery element is connected between the base and the second protrusion, the second shape memory alloy element contracts after being electrified and heated to actuate the braking element to rotate towards the movable position, and the second recovery element contracts to actuate the braking element to rotate towards the braking position after the second shape memory alloy element is powered off.

14. The adjustment module according to claim 9, wherein each of the second shape memory alloy element and the second recovery element is in the shape of a straight line.

15. The adjustment module according to claim 9, wherein a material of the second recovery element is a shape memory alloy.

16. The adjustment module according to claim 9, wherein the braking element has a positioning groove, the base has a protrusion, the protrusion is located at a first end of the positioning groove when the braking element is located at the braking position, the protrusion is located at a second end of the positioning groove when the braking element is located at the movable position, a neck portion of the positioning groove is located between the first end and the second end, and a width of the neck portion is slightly less than a width of the protrusion.
