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WO-A2-02/054132
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DESCRIPTION

BACKGROUND

[0001] Magnified telescopic sights, such as rifle scopes and spotting scopes, for example, frequently suffer from very small exit pupil size. When the exit pupil diameter of the device is approximately the same size or smaller than the diameter of the pupil of the operator's eye, it is increasingly difficult to keep the eye within the effective eyebox of device. Moving the eye out of the eyebox results in severe vignetting or total loss of the observed image.

[0002] For example, if the diameter of the exit pupil of a telescope is about 2 millimeters (mm) or less, the operator must try to keep his/her head extremely stable, even if the device is equipped with a tripod, in order to keep the eye within the eyebox. Very small, sub-millimeter movements of the operator's head can have significant impact. Therefore, even people who are trained to work with instruments having tight eyeboxes, such as snipers or competitive sports shooters, for example, may be not able to keep their heads sufficiently stable, particularly under such circumstances as intensive physical effort (for example, after a fast run), stress, or exhaustion. In addition, it may take several seconds to achieve proper match of the operator's eye and the eyebox of the device.

[0003] In view of these difficulties, it is highly desirable to have the size of the eyebox significantly larger than the size of the pupil of the eye. However, conventionally this requirement leads to larger front optics and increased total length of the device, particularly for devices with higher magnification. First principles of geometric optics dictate that it is not possible to generate a large exit pupil in combination with a relatively small entrance pupil and magnification of the telescope significantly larger than one. This is because the magnification of an afocal telescope is given by the ratio of the diameter of the entrance pupil to the diameter of the exit pupil. Thus, for example, if the diameter of exit pupil is 2 mm and the required magnification is 25X, the resulting diameter of entrance pupil is 50 mm. A typical length estimate for such a telescope is then at least 28-31 cm (11-12 inches), if not significantly more. Doubling the diameter of the exit pupil to 4 mm, which would significantly improve matching the eye to the eyebox, causes a corresponding increase in the entrance pupil diameter to 100 mm, and this results in a telescope that is too heavy and too long to use as a riflescope or portable spotting telescope.

[0004] JP H09 171147 A describes a primary image of an body which is enlarged by an objective is enlarged by an ocular into a secondary image which is a virtual image. The pupil moving means is provided nearby the primary image (aerial image) and the angle of deflection of the pupil moving means is varied corresponding to the pupil position of the eyeball of the observer. The pupil position of the eyeball of the observer is detected, for example, by arranging a spot light source slantingly before the eyeball and detecting the reflection position of the light from the spot light source. A variable vertical angle prism is used as the pupil moving means.

[0005] EP 1 131 663 A1 describes an optical instrument, such as a microscope or a camera, which is provided for forming a viewable image of an object. The optical instrument comprises an objective lens for forming the viewable image at an image plane, an eyepiece through which the user can view the viewable image at the image plane, an eye sensor for sensing the direction of gaze of a user viewing the viewable image and means for controlling a controllable function of the optical instrument in dependence upon the sensed direction of gaze. The eye sensor comprises a light source for outputting light through the eyepiece towards the user's eye, a lens associated with the light source for causing the light from the source to be substantially columnated when it exits the eyepiece towards the user's eye, an imaging transducer for imaging the front of the user's eye through the eyepiece and for generating an electrical image signal of the front of the user's eye and processing means for processing the electrical image signal to determine the location of the user's pupil centre and the location of a reflection of the light from said light source to determine therefrom the gaze information indicative of the direction of gaze of the user.

[0006] US 2010/302499 A1 describes an image display device for optically displaying an image. The device includes: a light source; an imaging-light generator converting light emitted from the light source, into imaging light representative of the image to be displayed to a viewer, to thereby generate the imaging light; and an exit-pupil controlling unit configured to control a position of an exit pupil of the image display device. The exit-pupil controlling unit includes: an electrically controllable element configured to diffract the imaging light incoming from the imaging-light generator, at an electrically-variable diffraction angle; and a controller configured to electrically control the diffraction angle of diffracted light emitted from the electrically controllable element, to thereby control the position of the exit pupil.

[0007] US 2013/169925 A1 describes corrective alignment optics for an optical device.

[0008] WO 02/054132 A2 describes a device containing an automatic zoom lens, and more particularly a zoom lens that is controlled by a processor that is linked to a gaze tracking system.

[0009] US 4 779 867 A describes an objective lens system having a pair of plano-convex lenses disposed adjacent each other with the convex surfaces facing each other and aligned along common optical axis.

SUMMARY OF INVENTION

[0010] Conventionally, the need for a large exit pupil combined with high magnification inevitably results in large, heavy and very expensive telescopes. Since the problem is fundamental, and largely resulting from first principles of geometrical optics, there is little that can be done to address the problem by optics alone. Accordingly, there is a need for a solution to this problem which may offer a larger eye box without demanding larger, longer, and heavier telescopes. Aspects and embodiments are directed to a system that expands the eyebox of an optical instrument, such as a rifle scope, spotting scope, microscope, borescope, or endoscope, by following the spatial movements of the operator's eye or head with the original small eyebox of the optical instrument, as discussed in more detail below. The invention is defined by the independent claims. Preferred embodiments are listed in the dependent claims.

[0011] According to one embodiment, an apparatus comprises an optical imaging device including: front optics configured to receive electromagnetic radiation and focus the electromagnetic radiation onto an intermediate focal plane; an optical deflector unit; and an eyepiece configured to focus the electromagnetic radiation from the intermediate focal plane to the eye and produce a real exit pupil located remote from the eyepiece, an infrared illuminator unit configured to project infrared electromagnetic radiation onto an eye of an operator of the optical imaging device, an eye-shift sensor unit configured to produce an image of the eye illuminated by said infrared illuminator unit, the image of the eye including a spot representative of the exit pupil, and a digital image processor unit coupled to the eye-shift sensor unit and configured to receive and process the image of the eye to determine an offset between an iris of the eye and the exit pupil, and to generate feedback data based on the offset. The optical deflector unit is coupled to the digital image processor unit, and is configured to receive the feedback data from the digital image processor unit, and to decenter the field lens in two orthogonal axes relative to an optical axis of the optical imaging device to relocate the exit pupil of the optical imaging device responsive to the feedback data to reduce the offset between the iris of the eye and the exit pupil.

[0012] In one example, the eye-shift sensor unit includes a digital camera. The optical deflector unit may be positioned within the eyepiece, or between the front optics and the eyepiece, for example. In one example the optical deflector unit is positioned between the intermediate focal plane and the exit pupil, proximate the intermediate focal plane. In one example the optical deflector unit includes a field lens. The optical imaging device may be a telescopic sight (e.g., a rifle scope or spotting scope), a microscope, or an endoscope, for example.

[0013] According to another embodiment, a method of automatically adjusting an eyebox of an optical imaging device comprises imaging an eye of an operator of the optical imaging device to produce an image of the eye, the image of the eye including a spot representative of an exit pupil of the optical imaging device, wherein imaging the eye includes illuminating the eye with infrared electromagnetic radiation, analyzing the image of the eye with a digital image processor unit to determine a relative offset between an iris of the eye and the exit pupil of the optical imaging device, generating feedback data with the digital image processor unit based on the determined relative offset between the iris of the eye and the exit pupil of the optical imaging device, providing the feedback data from the digital image processor unit to an optical deflector unit associated with the optical imaging device, the optical deflector unit including a field lens, and controlling the optical deflector unit, wherein controlling the optical deflector unit includes controlling decentering of the field lens in two orthogonal axes relative to an optical axis (140) of the optical imaging device to re-position the exit pupil of the optical imaging device responsive to the feedback data to compensate for the relative offset between the iris of the eye and the exit pupil to re-center the exit pupil with the eye.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014] Various aspects of at least one embodiment are discussed below with reference to the accompanying figures, which are not intended to be drawn to scale. The figures are included to provide illustration and a further understanding of the various aspects and embodiments, and are incorporated in and constitute a part of this specification, but are not intended as a definition of the limits of the invention. In the figures, each identical or nearly identical component that is illustrated in various figures is represented by a like numeral. For purposes of clarity, not every component may be labeled in every figure. In the figures:

FIG. 1 is a block diagram of one example of a system including an electronic eyebox according to aspects of the invention; and

FIG. 2 is a flow diagram of one example of a method of automatically adjusting the electronic eyebox according to aspects of the invention

DETAILED DESCRIPTION

[0015] Aspects and embodiments are directed to a system that automatically expands the eyebox of an optical imaging device to improve ease of use of the telescope without requiring larger, heavier optics. Examples of optical imaging devices in which embodiments of the system may be used include, but are not limited to, telescopic sights (such as rifle scopes or spotting scopes, for example), microscopes, endoscopes, or other optical imaging devices which have an eyepiece that produces a remotely located real exit pupil for use by a human operator. As discussed in more detail below, the system is configured to track the movement of an operator's eye, and automatically cause the eyebox, including the exit pupil, to follow the movement of the eye. Thus, the system creates operator perception of an expanded eyebox by following the spatial movement of the eye with the eyebox of the telescope. In this manner, an operator does not experience significant vignetting or loss of the imaged field of view (FOV) even when moving the head and/or hands. As discussed in more detail below, in one embodiment the system includes a magnified telescopic sight, either with a prismatic erector or a lens-based erector, an infrared illuminator unit which projects infrared radiation onto a moving eyeball, an eye-shift sensor unit (for example a miniature camera) that observes the illuminated eyeball, a digital image processor unit which receives image from the sensor unit and calculates feedback data, and an optical deflector which receives the correction data and relocates the exit pupil of the telescope to the correct location in which it will be centered on the iris of the eye The perception, and benefits, of a larger eyebox may thus be created without requiring significant changes to the optics of the telescope, and substantially without affecting the size of the entrance pupil, field of view, and magnification of the telescope.

[0016] Referring to FIG. 1, there is illustrated a block diagram of one example of a system incorporating an electronic eyebox according to aspects of the present invention. As discussed above, the system may be implemented in any type of optical imaging device or telescope, including, but not limited to, rifle or other weapon scopes or sights, spotting scopes, and other devices having an eyepiece that produces a remotely located real exit pupil. The telescope includes front optics 110 which include the aperture stop of the telescope. The telescope further includes an eyepiece 115. Together, the front optics 110 and eyepiece 115 direct and focus incident electromagnetic radiation onto the operator's eye 120 to allow the operator to view an imaged scene. To effectively view the scene (or entire imaged field of view), the operator must place his/her eye 120 in a plane where the exit pupil 125 of the telescope is formed. At the exit pupil, the focused electromagnetic radiation forms a "bright spot" which may be imaged to reveal the location of the exit pupil, as discussed further below. In one embodiment, the front optics 110 and eyepiece 115 together provide a magnified telescopic sight. Although not illustrated in FIG. 1, the sight may include either a prismatic erector or a lens-based erector for image formation, as known to those skilled in the art.

[0017] The system further includes an optical deflector unit 130 that is configured to adjustably deflect the beam of electromagnetic radiation received from the front optics 110 to compensate for movement of the eye 120, as discussed further below. As the eye 120 moves away from the optical axis 140 of the telescope, the optical deflection unit 130 redirects the beam of electromagnetic radiation 135 so effectively "move" the original eyebox of the telescope (including the exit pupil 125) to follow the movement of the eye 120, as shown in FIG. 1. Circle 165 represents the original location of the exit pupil 125. As the eye 120 moves, the optical deflector unit 130 repositions the exit pupil 125 to location 170, such that the exit pupil is re-centered on the eye 120. Circle 175 represents the boundary of the "electronic eyebox" which is created by moving the exit pupil 125 to follow the movement of the eye 120. As may be seen in FIG. 1, the electronic eyebox bounded by circle 175 may be significantly larger than the diameter of the original exit pupil 125. The diameter of the boundary circle 175 may be determined, at least in part, by the angular range over which the optical deflector unit 130 may redirect the beam of electromagnetic radiation 135.

[0018] Thus, through provision of the larger electronic eyebox, the operator will not experience vignetting or loss of the imaged field of view even when moving the head and/or hands. In contrast, conventionally, such movement of the operator's head and/or hands would result in a mismatch between the location of the eye 120 and the location of the exit pupil 125, resulting in vignetting and/or loss of the imaged field of view, as discussed above. Although the physical size of eyebox remains unchanged, the eyebox is "delivered" to the current location of the eye 120, as illustrated in FIG. 1. Control of movement of the eyebox (eyebox delivery) may be effected using either of two methods, as discussed in more detail below. In one embodiment, eyebox delivery is accomplished with a closed loop control mode using an eye pupil tracking device integrated into the telescope. In another embodiment, eyebox delivery is accomplished using an open loop control mode in which the eyebox is periodically replicated in time at the position where the eye 120 is currently located by continuous or discrete scanning over the space of interest.

[0019] According to one embodiment, the original optical parameters of the telescope in which the electronic eyebox is implemented, such as magnification, field of view, eye relief, etc., may remain substantially unchanged. The eyepiece portion of the telescope may be modified to accommodate the optical deflector unit 130. In one embodiment, the optical deflector unit 130 is part of the eyepiece 115. However, the optical deflector unit 130 may be either internal or external with respect to the telescope. As illustrated in FIG. 1, the optical deflector unit 130 is located after the final intermediate focal plane 145 and therefore its action does not change relationship between the image of a viewed target and the reticule. In other words, line of sight and aiming are not disturbed by the action of the optical deflector unit 130. In contrast, deflector units in conventional telescopes having image stabilization always change line of sight while keeping the image stable in the focal plane. Such conventional devices are not suitable for shooting. However, aspects and embodiments of the electronic eyebox described herein may be implemented in image-stabilized telescopes used for observation only (such as binoculars or spotting scopes, for example). In such embodiments, the resulting device includes both an image-stabilizing deflector and the optical deflector unit 130, and may provide both a stabilized image and electronic eyebox capability.

[0020] According to one embodiment, it may be preferred that the optical deflector unit 130 is located as close as possible to the final intermediate focal plane 145, such that its action on the final image as observed in the eye is negligible. This is a consequence of the fact that the final image is a geometric optical conjugate of the intermediate image. Thus, in this configuration, the optical deflector unit 130 may have little to no effect on the final image, while producing maximum scan effect on the exit pupil of the optical system.

[0021] According to another embodiment, the optical deflector unit 130 may be located further away from the intermediate focal plane 145. In this case, the optical deflector unit 130 may produce both useful exit pupil movement, as discussed above, and also movement of the final image on the retina of the eye 120. An operator may perceive this image movement as wandering of the observed target when using the electronic eyebox; however, this may be acceptable in certain applications and/or depending on the magnitude of the wander effect. Additionally, in practice it may not be possible to achieve perfect collimation of the optical beam, or perfect parallelism between the deflected collimated beam and the initial collimated beam in the eye-space, even when the optical deflector unit 130 is positioned approximately at the intermediate focal plane. As a result, some wandering of the beam in the eye-space may occur, and there may be certain locations of the optical deflector unit 130 in the optical train at which these effects are worsened. Accordingly, a system designer may select the location of the optical deflector unit 130 in the optical train with these considerations, such that appropriate tracking of the eye movement may be achieved while any beam wander may be maintained within acceptable limits.

[0022] Since in certain embodiments it may be preferable to position the optical deflector unit 130 at or very close to the intermediate focal plane 145, the optical deflector unit 130 may be implemented using a "field lens." Field lenses are used in eyepieces and optical relays, and by definition, the field lens is inserted very close to the intermediate focal plane such that it does not change the magnification or field of view of the optical system. The field lens does change the eye relief, and a relatively strong negative lens may significantly increase the eye relief of a scope, for example. By controlling the X and Y decentering of a field lens (X and Y denoting shifts orthogonal to the optical axis of the telescope), appropriate relocation of the exit pupil 125 may be achieved to follow the movement of the eye 120, as discussed above. In other examples, the optical deflector unit 130 may include any of numerous well-known adjustable beam-deflecting devices, including, for example, a Risley prism, one or more tiltable mirrors, a mechanical wedge, a liquid wedge, and the like.

[0023] Still referring to FIG. 1, as discussed above, in one embodiment tracking of movement of the eye 120 is accomplished using an infrared illuminator 150, and eye-shift sensor unit 155, and a digital image processor unit 160, in combination with the optical deflector unit 130. The digital image processor unit 160 is coupled to the eye-shift sensor unit 155 and the optical deflector unit 130. The infrared illuminator unit 150 is configured to project infrared electromagnetic radiation onto the eye 120, thereby illuminating the eye. The infrared illuminator unit 150 may project a beam of infrared radiation, or in some examples, a structured pattern (such as a rectangular grid, for example) of infrared illumination onto the eye 120 (and optionally surrounding facial features or regions). The infrared illuminator unit 150 is configured to illuminate the eye 120 with infrared electromagnetic radiation because the infrared spectral band is invisible to the human eye, and therefore will not interfere with the operator's ability to view the imaged field of view of the telescope. Additionally, using infrared radiation also prevents the operator's face from being visibly illuminated and his/her location from being revealed in darkness or low light as a result.

[0024] The eye-shift sensor unit 155 is configured to observe and image the illuminated eye 120 and the exit pupil 125 of the telescope. In one example, the eye-shift sensor unit 155 includes a camera, in particular, a digital camera, that provides digital images of the eye 120. As discussed above, the electromagnetic radiation focused by the telescope forms a "bright spot" at the exit pupil. The eye-shift sensor unit 155 may image this bright spot when it is projected onto a surface, for example, the eye 120 or other facial regions, which reveals the location of the exit pupil 125, along with the illuminated eye 120. The eye-shift sensor unit 155 is coupled to the digital image processor unit 160 and provides the digital images to the digital image processor unit 160. The digital image processor unit 160 may process the images obtained from the eye-shift sensor unit 155 to determine and compare the location of the exit pupil 125 relative to the location of the iris of the eye 120. Based on this analysis, the digital image processor unit 160 may calculate feedback data that is provided to the optical deflector unit 130 to control the optical deflector unit 130 to change the angle of deflection of the electromagnetic radiation output therefrom and thereby relocate the exit pupil 125 to the correct location in which it will be approximately centered on the iris of the eye 120.

[0025] Referring to FIG. 2 there is illustrated a flow diagram of one example of a method of controlling the exit pupil location in a telescope according to one embodiment. As discussed above, in a first step 210, the infrared illuminator unit 150 is operated to illuminate the eye 120. In step 220, the eye-shift sensor unit 155 is operated to obtain an image of the illuminated eye 120. As discussed above, the image also contains an image of the "bright spot" formed by the focused electromagnetic radiation at the exit pupil 125 of the telescope. In step 230, the digital image processor unit 160 analyzes the image to determine a relative offset between the exit pupil (identified by the bright spot in the image) and the iris of the eye. Generally, both the iris of the eye 120 and the exit pupil 125 are approximately circular, and therefore the digital image processor unit may be configured to detect and extract the locations of two approximately circular features both having their diameters approximately known. A common image processing technique by which to accomplish this task is to use the Hough Transform, as known and understood by those skilled in the art. In another example, the digital image processor unit 160 may performed a centroiding operation to determine the approximate center of each of the bright spot and the iris of the eye in the image. However, any of numerous well known image processing techniques may be used to determine the relative positioning of the iris of the eye 120 and the exit pupil 125 of the telescope. Based on the determined relative offset between the exit pupil 125 and the iris of the eye 120, the digital image processor unit 160 may calculate feedback data (step 240) which may be used to control the optical deflector unit 130 to reposition the exit pupil (step 250), as discussed above.

[0026] According to one embodiment, steps 210-250 may be performed as part of a closed loop feedback process in which the position of the exit pupil 125 is continuously or periodically (at regular or irregular intervals) relocated to maintain a sufficient match between the eye 120 and the exit pupil. In one example, the eye-shift sensor unit 155 may include a relatively high speed digital camera, for example, up to 60 frames per second, or higher, that is capable of very quickly producing images of the eye 120. Similarly, the digital image processor unit may be able to process the images and generate the feedback data multiple times per second. The optical deflector unit 130 may also be a relatively high speed device, for example, capable of operating at approximately 100 Hz, although even somewhat slower speeds for the deflector may be sufficient. Thus, with such devices operating in a closed loop feedback process, it may be possible to adjust the position of the exit pupil 125 sufficiently quickly so as to track small, relatively fast motion of the operator's eye 120 and such that the operator has the perception of a significantly larger eyebox.

[0027] Thus, aspects and embodiments may provide an apparatus in which automatic matching of the exit pupil of the optical imaging device to an operator's shifting eye may be accomplished. This may provide greatly improved ability to maintain the match even as the operator's eye, head, or hands make small movements, and may be achieved without requiring large, heavy optics. As discussed above, according to one embodiment, user perception of an expanded eyebox of a terrestrial telescope may be created by following the spatial movements of the eye/head with the original small eyebox of the telescope. In general, original optical parameters of the telescope, such as magnification, field of view, and eye relief, for example, may be substantially unchanged. Additionally, as discussed above, the optical deflector unit used to reposition the exit pupil may be located after the final intermediate focal plane of the telescope, and therefore its action does not change relationship between the image of the target and the reticule. As a result, line of sight and aiming are not disturbed by the action of the optical deflector unit. Additionally, placing the optical deflector unit at or proximate to the final intermediate focal plane may minimize any image wander caused by deflection that does not originate in the intermediate focal plane.

REFERENCES CITED IN THE DESCRIPTION

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- EP1131663A1 [0005]
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Patentkrav

1. Apparat omfattende:

en optisk billeddannelsesindretning omfattende:

forreste optik (110) konfigureret til at modtage elektromagnetisk stråling og fokusere den elektromagnetiske stråling på et mellemliggende fokalplan (145);

en optisk deflektorenhed (130); og

et okular (115) konfigureret til at fokusere den elektromagnetiske stråling fra det mellemliggende fokalplan til et øje (120) af en operatør og fremstille en udgangspupil (125) lokaliseret fjernt fra okularet;

en infrarød belysningsenhed (150) konfigureret til at projicere infrarød elektromagnetisk stråling på øjet af operatøren af den optiske billeddannelsesindretning;

en øjen-forskydnings-sensorenhed (155) konfigureret til at fremstille et billede af øjet belyst af den infrarøde belysningsenhed, billedet af øjet omfattende en plet repræsentativ for udgangspupillen; og

en digital billedprocessorenhed (160) koblet til øjen-forskydnings-sensorenheden og konfigureret til at modtage og behandle billedet af øjet for at bestemme en forskydning mellem en iris af øjet og udgangspupillen, og for at generere feedbackdata baseret på forskydningen;

hvor den optiske deflektorenhed (130) er koblet til den digitale billedprocessorenhed og omfatter en feltlinse positioneret mellem det mellemliggende fokalplan og udgangspupillen, nærmest fokalplanet, idet den optiske deflektorenhed er konfigureret til at modtage feedback-dataet fra den digitale billedprocessorenhed, og til at decentrere feltlinsen i to ortogonale akser i forhold til en optisk akse (140) af den optiske billeddannelsesindretning for at relokere udgangspupillen af den optiske billeddannelsesindretning som svar på feedback-dataet for at reducere forskydningen mellem øjets iris og udgangspupillen.

2. Apparatet ifølge krav 1, hvor øjen-forskydnings-sensorenheden (155) omfatter et digitalkamera.

3. Apparatet ifølge krav 1, hvor den optiske billeddannelsesindretning er et teleskopisk sigtemiddel.

4. Apparatet ifølge krav 1, hvor den optiske deflektorenhed (130) er positioneret inde i okularet (115).

5. Apparatet ifølge krav 1, hvor den optiske deflektorenhed (130) er positioneret mellem den forreste optik (110) og okularet (115).

6. Fremgangsmåde til automatisk justering af en øjenboks af en optisk billeddannelsesindretning, hvilken fremgangsmåde omfatter at:

billeddanne et øje (120) af en operatør af den optiske billeddannelsesindretning for at fremstille et billede af øjet, billedet af øjet omfattende en plet repræsentativ for en udgangspupil (125) af den optiske billeddannelsesindretning, hvor billeddannelse af øjet (120) omfatter belysning af øjet med infrarød elektromagnetisk stråling;

analysere billedet af øjet med en digital billedprocessorenhed (160) for at bestemme en relativ forskydning mellem en iris af øjet og udgangspupillen af den optiske billeddannelsesindretning;

generere feedbackdata med den digitale billedprocessorenhed (160) baseret på den bestemte relative forskydning mellem øjets iris og udgangspupillen af den optiske processorindretning;

tilvejebringe feedback-dataet fra den digitale billedprocessorenhed til en optisk deflektorenhed (130) associeret med den optiske billeddannelses-indretning, den optiske deflektorenhed omfattende en feltlinse; og styre den optiske deflektorenhed (130), hvor at styre den optiske deflektorenhed omfatter af styre decentrering af feltlinsen i to ortogonale akser i forhold til en optisk axis (140) af den optiske billeddannelsesindretning for at repositionere udgangspupillen af den optiske billeddannelsesindretning som svar på feedback-dataet for at kompensere for den relative forskydning mellem øjets iris og udgangspupillen til recentrering af udgangspupillen med øjet.

DRAWINGS

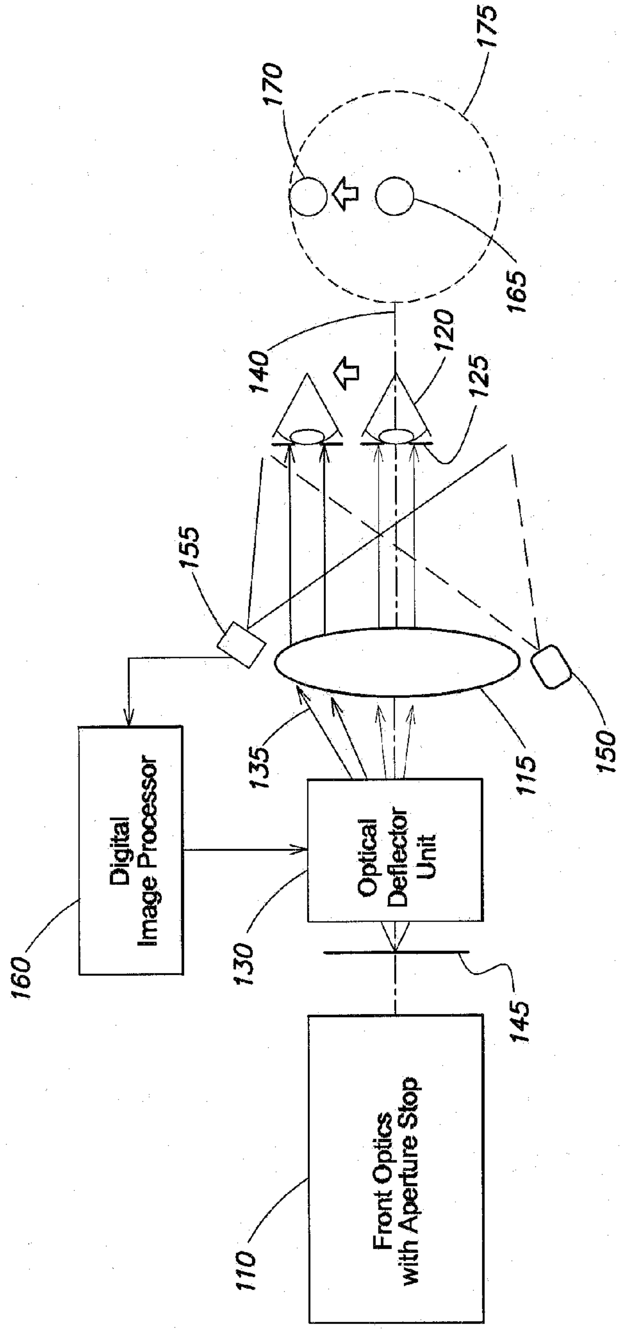

FIG. 1

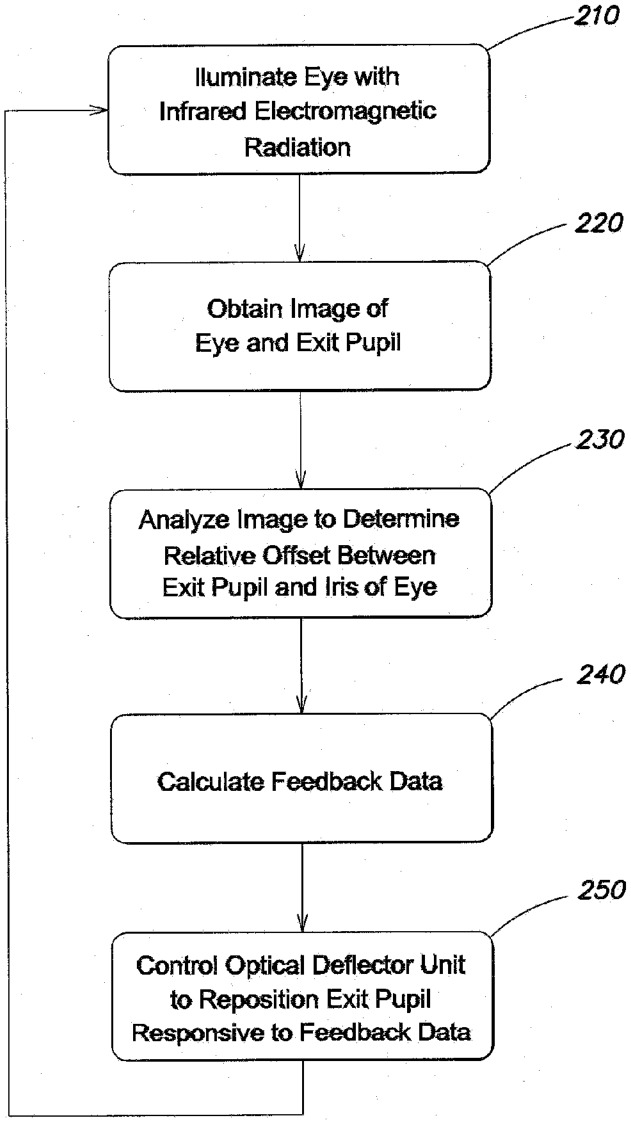
210
Iluminate Eye with Infrared Electromagnetic Radiation
220
Obtain Image of Eye and Exit Pupil
230
Analyze Image to Determine Relative Offset Between Exit Pupil and Iris of Eye
240
Calculate Feedback Data
250
Control Optical Deflector Unit to Reposition Exit Pupil Responsive to Feedback Data

FIG. 2