AN EYE TESTING DEVICE AND METHODS OF USING THE SAME

TECHNICAL FIELD

The present disclosure generally relates to an eye testing device used to detect and monitor functional visual field loss.

BACKGROUND

Screening and routine testing are important steps in detecting and monitoring functional visual field loss, especially for subjects suffering from glaucoma. Visual field loss is commonly observed in subjects aged 50 or above. As patients get older, they tend to be less mobile thus going for appointments at tertiary care or hospital to get their eyes checked is less likely, especially when these subjects did not observe any abnormalities with their eyes. However, if the unobserved age-related vision changes are due to glaucoma, it is likely that by the time the reach the hospital, these subjects would have lost most of their peripheral visual field, which could have been prevented if a visual field-testing device is made more accessible for these subjects.

Humphrey visual field device (HFA) is the gold standard in screening and monitoring functional visual field loss. Occasionally, eye screening exercise is held in the primary care to screen for functional visual field loss. The device, however, requires the infrastructure and capital that makes the screening not widely available.

In view of the above challenges, therefore there is a need to provide an eye testing device that allows the screening and monitoring functional visual field loss to be more affordable and more importantly allowing such a screening to be widely available and accessible.

SUMMARY

There is provided an eye testing apparatus. Said testing apparatus may be used for visual field testing. The testing apparatus may include an illumination panel for generating light stimulus towards an opening, said light stimulus comprising light having wavelength from visible to infrared region and an optical module. The optical module may comprise a lens positioned at a predefined distance from the opening and an infrared (IR)-reflecting mirror positioned between the illumination panel and the lens, said IR-reflecting mirror may be inclined towards the illumination panel and may allow visible light stimulus from the

illumination panel to an eye of a subject. The testing apparatus may further comprise an infrared (IR) camera configured to capture an image of the eye reflected by the IR-reflecting mirror that has been focused by a camera lens.

Optionally, the illumination panel of the apparatus may be positioned at a distal end of the device and said opening may be located at a proximal end of the device. Optionally, the IR camera may be positioned such that the eye in the image captured by the IR camera is concentric.

In accordance with some embodiments of the present disclosure, the lens may be a flat lens. The flat lens may be a Fresnel lens for focusing the visible light stimulus seen by the eye of the subject.

Optionally, the testing apparatus may further comprise a plurality of illumination source positioned at the opening of the apparatus. The plurality of illumination source may be provided on a ring. The plurality of illumination source may comprise 4, 6, 8 or 10 illumination sources disposed on the ring. Optionally, the plurality of illumination source may comprise one or more infrared light emitting diodes (IR LEDs).

Optionally, the IR-reflecting mirror may be inclined at a predefined angle of about 40^{o} to 70^{o}, preferably about 55^{o}.

In accordance with some embodiments of the present disclosure, the illumination panel, optical module and IR camera may be located within a housing. The device may optionally further comprise a positioning mechanism connected to the housing to allow a user to adjust the position of said apparatus.

Further, there is also provided a method of determining the visual field of the eye of the subject. The method may be performed using the apparatus described herein. Said method may comprise the steps of positioning an eye of a subject on an opening at proximal end of a testing apparatus, directing light stimulus generated by an illumination panel towards said opening, said light stimulus comprising light having wavelength from visible to infrared region, transmitting visible light from the light stimulus through an infrared (IR)-reflecting mirror in the apparatus to be seen by the eye of the subject, said IR-reflecting mirror may be inclined towards the illumination panel, focusing the visible light stimulus seen by the eye of the subject by means of a lens positioned at a predefined distance from the opening and reflecting the infrared light from the infrared (IR)-reflecting mirror to an infrared (IR) camera such that an image of the eye is captured.

Optionally, the method may further comprise determining the visual field of the eye of the subject by means of identifying whether the subject is able to see the light stimulus.

Optionally, in accordance with some embodiments of the present application, said lens in the apparatus is a flat lens. The flat lens in the apparatus may be a Fresnel lens for focusing the visible light stimulus seen by the eye of the subject.

As will be described below, the eye testing device described in the present disclosure is user-friendly and easy to use, for example by simply following instructions to operate the device. Hence, advantageously the device may be considered as being self-administered. Yet advantageously, the implementation of the device may not require a specialized operator to administer the test. Thus, the user (for example an individual undergoing the test) may interact with the device owing to simple instructions to operate the device.

Advantageously, the device disclosed herein may also administer visual field test assessment wirelessly thus it may open a possibility of telemedicine. With telemedicine capabilities, advantageously, a specialist for example an ophthalmologist does not require to be onsite to analyze the test results as the readings obtained from the device may be transmitted directly to a device of the ophthalmologist for analysis.

Further advantageously, the device disclosed in the present disclosure has a small form factor that enables it to be placed on typical desktop arrangement. Further, owing to the small form factor, the device may require reduced power consumption but provide greater portability.

As the lens used in the device is commercially and widely available at low cost, the production costs of the device may be reduced significantly. This may potentially solve the issues associated with the limited infrastructure and buying power faced in the primary care settings including polyclinics and general practitioners.

BRIEF DESCRIPTION OF THE DRAWINGS

Some non-limiting exemplary embodiments or features of the disclosed subject matter are illustrated in the following drawings.

In the drawings:

Fig. 1 schematically illustrates the working principle of the device showing the light stimulus generated by the illumination panel and the optical path, in accordance with some embodiments of the present disclosure;

Fig. 2A illustrates an example of implementation of the device where a user is interacting with the device via a user interface, in accordance with some embodiments of the present disclosure;

Fig. 2B schematically illustrates the testing device described in Fig. 2A showing the various components of the device, in accordance with some embodiments of the present disclosure; and

Fig. 3 illustrates a block diagram showing the interactions between the various components of the device and other external devices or external network for transmitting and displaying the test results, in accordance with some embodiments of the present disclosure.

With specific reference now to the drawings in detail, it is stressed that the particulars shown are by way of example and for purposes of illustrative discussion of embodiments of the disclosure. In this regard, the description taken with the drawings makes apparent to those skilled in the art how embodiments of the disclosure may be practiced.

Identical or duplicate or equivalent or similar structures, elements, or parts that appear in one or more drawings are generally labeled with the same reference numeral, optionally with an additional letter or letters to distinguish between similar entities or variants of entities, and may not be repeatedly labeled and/or described. References to previously presented elements are implied without necessarily further citing the drawing or description in which they appear.

Dimensions of components and features shown in the figures are chosen for convenience or clarity of presentation and are not necessarily shown to scale or true perspective. For convenience or clarity, some elements or structures are not shown or shown only partially and/or with different perspective or from different point of views.

DETAILED DESCRIPTION

There is provided an eye testing apparatus. In some embodiments, said eye testing apparatus is used for visual field testing. In some embodiments, the apparatus comprises an illumination panel, an optical module and a camera. In some embodiments, the illumination panel may generate light stimulus towards an opening of the testing apparatus, said light stimulus comprising light. In some embodiments, the light may comprise light in ultraviolet (UV), visible and infrared (IR) regions. Range of the wavelength for each of the regions is known to a person skilled in the art. For example, a person skilled in the art will understand that visible light may have a wavelength from about 380 nm to about 780 nm. Similarly, a

person skilled in the art will understand that the infrared light may have a wavelength from about 700 nm to about 1000 nm (near infrared). It is also understood that this range may be wider if mid infrared and far infrared regions are included (up to 1 mm).

In some embodiments, the optical module of the device or the apparatus described herein comprises the following elements: a lens and an infrared (IR)-reflecting mirror. In some embodiments, the apparatus comprises a lens positioned at a predefined distance from the opening and the IR-reflecting mirror positioned between the illumination panel and the lens. In some embodiments, said IR-reflecting mirror is inclined towards the illumination panel. In some embodiments, the IR-reflecting mirror allows visible light stimulus from the illumination panel to an eye of a subject. In some embodiments, the IR-reflecting mirror is inclined towards the illumination panel and allows visible light stimulus from the illumination panel to an eye of a subject. In some embodiments, the IR-reflecting mirror is inclined at a predefined angle (α) of about 40^o to 70^o, preferably about 55^o. In some embodiments, the predefined angle may be about 40^o, 45^o, 50^o, 55^o, 60^o, 65^o, or 70^o. As stated above, the predefined angle is preferably 55^o as this angle advantageously provides arrangement of the elements or components of the device such that the size of the device may be suitable for being hand-held. In some embodiments, other suitable predefined angles between the range defined above may also be used.

In some embodiments, the camera may be an infrared (IR) camera configured to capture an image of the eye reflected by the IR-reflecting mirror that has been focused by a camera lens.

In some embodiments, the visual field testing apparatus described herein may comprise an illumination panel for generating light stimulus towards an opening, the light stimulus comprising light having wavelength from visible to infrared region and an optical module, the optical module comprising a lens positioned at a predefined distance from the opening and an infrared (IR)-reflecting mirror positioned between the illumination panel and the lens, said IR-reflecting mirror is inclined towards the illumination panel and allows visible light stimulus from the illumination panel to an eye of a subject and an infrared (IR) camera configured to capture an image of the eye reflected by the IR-reflecting mirror that has been focused by the camera lens.

In some embodiments, while other suitable arrangement or configuration may be used, preferably, the illumination panel is positioned at a distal end of the device and said opening is located at a proximal end of the device.

As described herein, the device disclosed in the current application has a unique optical design and positioning mechanism. Advantageously, the optical design for the camera ensures that the pupil will be seen concentric with respect to the camera lens while the user is performing the test. In some embodiments, the camera is tilted to a specific angle as defined herein to ensure a smaller footprint is achieved without compromising the concentricity and magnification. Advantageously, this may ensure that the test is conducted at the most ideal position for the most accurate results. Further advantageously, in some embodiments and as can be seen at least from Figs.2A and 2B, the system may further include a positioning mechanism allowing the device to be adjusted in 3D space. In some embodiments, the adjusting or positioning mechanism of the system may include three individual axis control that allows accurate positioning and fine movement knobs paired with positional grading ensuring ease of use for the user to position the device.

In some embodiments, the IR camera is positioned such that the eye in the image captured by the IR camera is concentric. In some embodiments, the determination that the eye in the image appears substantially concentric is used to facilitate that the eye is ready (or at the right, proper or adequate position) to be tested. Non-concentric appearance of the eye in the image captured by the IR camera may require the user to readjust his or her position before proceeding with the test. In some embodiments, as will be described below, non-concentric appearance of the eye may prevent the camera lens from being focused.

In some embodiments, the lens of the device described herein is a flat lens. In some embodiments, the flat lens is a Fresnel lens for focusing the visible light stimulus seen by the eye of the subject. Advantageously, the Fresnel lens may be those commercially available that may be used as is without further modification. In some embodiments, the Fresnel lens may be made of polymeric-based material. The polymer of the polymeric-based material may include poly(methyl methacrylate) (PMMA). In some embodiments, the polymer may be provided in the form of homopolymer, co-polymer or mixture thereof. In some embodiments, the Fresnel lens may have the following technical specifications: index of refraction of from about 0.4 to 1.8 at a range of wavelength from about 350 nm to about 700 nm, flat profile, transparent and diameter of from 45 mm to 55 mm, for example 45 mm, 46 mm, 47 mm, 48 mm, 49 mm, 50 mm, 51 mm, 52 mm, 53 mm, 54 mm, or 55 mm. It is to be understood that other suitable technical specifications of the Fresnel lens may be used. For instance, lens diameter of more than 55 mm may be used provided that the lighting of the eye from the ring of IR light is sufficiently efficient as bigger ring of IR light will be required. In some embodiments, the lens diameter may be made smaller than 45 mm provided that a reasonable field of view is achieved.

In some embodiments, the Fresnel lens may have a focal length in a range from about 30 mm to about 80 mm for example about 35 mm, about 40 mm, about 50 mm, about 55 mm, about 60 mm or about 70 mm. As described herein, the focal length may refer to the distance between the lens and the human eye (or retina) when the lens is focused at infinity. In some embodiments, the focal length may determine the angle of view and/ or magnification of the image projected to the retina.

In some embodiments, while other type of lens (including for example spherical lens) than the flat lens may be used, the preferred embodiment of the lens used in the device disclosed herein is the flat lens since the flat lens provide low distortion at the edges of the lens. Hence, advantageously, lesser aberration correction at the edges will be required.

As described in the current disclosure including the drawings, the trajectory of light or the optical path may be determined by Snell's Law as shown in equation (i) below:

$$n_1 sin\theta_1 = n_2 sin\theta_2 \qquad \text{(i)}$$

where n_1 denotes a refractive index of incident media, θ_1 is angle of incident light, n_2 is a refractive index of refracted media and θ_2 is angle of refraction.

In some embodiments, using Snell's Law and trigonometry principle, the trajectory of light may be determined. In some embodiments, optical simulation of the setup of the device may be then performed. In some embodiments, shorter focal length may provide a larger field of view at the expense of lesser available working area between the lens and the screen. In some embodiments, said working area is necessary for the placement of the IR-reflecting mirror. As previously described, the IR-reflecting mirror allows the visible light from the illumination panel or screen to be directed towards the eye of the user. Concurrently, the IR-reflecting mirror reflects the IR image of the eye towards the IR camera.

In some embodiments, to provide better quality of images captured by the camera, a plurality of illumination source may be positioned at the opening of the apparatus. The plurality of illumination source may advantageously provide additional illumination to the eye of the user. This additional illumination may allow better quality of the images captured.

In some embodiments, the plurality of illumination source is provided on a ring. It is to be appreciated that other shapes or geometry including oval, and any other shape having arc portion may be used. In some embodiments, when the plurality of the illumination source is provided on the ring, the plurality of illumination source comprises 4, 6, 8, 10, 12 or 16

illumination sources disposed on the ring. In some embodiments, the plurality of illumination source may be spaced evenly on the ring. In some embodiments, the plurality of illumination source may comprise one or more infrared light emitting diodes (IR LEDs). When the plurality of illumination source comprises 4, 6, 8, 10, 12 or 16 illumination sources, such illumination source may accordingly comprise 4, 6, 8, 10, 12 or 16 IR LEDs. It is to be understood that other suitable illumination source than IR LEDs may also be used. In some embodiments, wavelength of the IR LEDs may be adjusted according to the needs. In an exemplary embodiment, the wavelength of the IR LEDs is set from about 920 nm to about 980 nm, preferably at 940 nm. Other wavelengths, for example in a range of about 850 nm to about 1100 nm may also be used.

In some embodiments, the elements or components of the device or apparatus described above may be substantially housed in a housing. In some embodiments, the illumination panel, the optical module and the IR camera of the device as described above may be located within a housing or substantially housed in a housing. In such an embodiment, said illumination panel, optical module and IR camera may therefore be placed within said housing. Accordingly, when the illumination panel, optical module and the IR camera are placed within the housing, it is to be understood that the lens and the IR-reflecting mirror are found within the housing. In some embodiments, the illumination panel, the flat lens (Fresnel lens), the IR-reflecting mirror, and the IR camera are positioned within the housing.

In some embodiments, the illumination panel as described herein may be provided in different sizes, shapes and made of different materials. In some embodiments, the illumination panel may be powered by a power source including but not limited to batteries, electricity and solar panels. In some embodiments, the illumination panel may comprise a screen including LCD display, LED display, OLED display, AMOLED display, TFT display and IPS display. In some embodiments, it may be necessary to “calibrate” the illumination panel such that the test result obtained from the device disclosed herein may be benchmarked or compared against the standard or reference test. In some embodiments, the standard or reference test is Humphrey’s visual field test.

In some embodiments, the calibration described above may be determined by means of differential light sensitivity (DLS). In some embodiments, DLS refers to a measure of stimulus intensity as a factor of background luminance. In some embodiments, stimulus attenuation scale in the Humphrey’s visual field analysis (HFA) may use Weber’s contrast or DLS that has been converted to decibels (dB) corresponding to the HFA maximum stimulus intensity of

10,000 apostilibs (abs) being defined as the brightest. In some embodiments, the HFA minimum stimulus intensity is 0.08 asb being the most dim.

The equations used for calculations and conversions are described below. Equation (ii) describes a ratio:

$$\frac{I}{\Delta I} \qquad \text{(ii)}$$

where I denotes background illumination and ΔI is change in brightness with respect to background illumination I. In some embodiments, equation (ii) may be rewritten as equation (iii) below:

$$C_w = \frac{L_s - L_b}{L_b} \qquad \text{(iii)}$$

C_w denotes Weber's contrast or DLS, L_s is the intensity of stimulus and L_b is the intensity of the background. In some embodiments, Weber's contrast or DLS in dB (S_{dB}) may be determined by equation (iv) below:

$$S_{dB} = 25 - 10\log\left(C_w\right) \quad \text{(iv)}$$

In some embodiments, equations (ii) – (iv) above are used for ensuring that the stimulus intensity between the device disclosed herein and HFA can be correlated.

According to some embodiments of the present disclosure, the eye testing device disclosed herein is a self-administered device. In such an embodiment, the subject (for example a patient) may perform the visual field test without assistance of a skilled labor including a nurse, assistant nurse or ophthalmologist.

In some embodiments, the device or apparatus described herein may be a hand-held device or a portable device. In such an embodiment, the device may be suitable for personal use or home-based use as there is no need for the user to visit clinics to perform the visual field tests. In some embodiments, the device may be mounted on a platform or arm, and the platform or the arm is fixed to a desk. For the latter, the device may be suitable to be used in hospitals or clinics. In some embodiments, the housing may be mounted on a positioning arm to facilitate the adjustment of the device.

In some embodiments, the device may include a user interface module. In some embodiments, said user interface module may comprise an identifier to identify and verify the identification of the users. The identification method that can be used is not limited to barcode or QR code scanning. Other suitable identification means may also be used. In some embodiments, the user interface may comprise a screen displaying the result of the visual field test.

In some embodiments of the disclosure, there is provided a method for conducting a visual field testing. In some embodiments, the visual field testing may be performed by using the device or apparatus as described in the present disclosure. In some embodiments, the method comprises positioning an eye of a subject on an opening at proximal end of a testing apparatus.

In some embodiments, when the device is activated i.e. switched on and is ready to perform the measurements, light stimulus generated by an illumination panel is substantially directed towards the opening of the device so that the light stimulus can be seen by the eye of the subject. In some embodiments, said light stimulus comprises light having wavelength from visible to infrared region. In some embodiments, the light stimulus comprises light having visible light. In some embodiments, the visible light may have a wavelength from about 380 nm to about 780 nm. In some embodiments, the light stimulus comprises light having infrared light. In some embodiments, the infrared light may have a wavelength from about 700 nm to about 1000 nm (near infrared). It is to be appreciated that this range may be wider if mid infrared and far infrared regions are included (up to 1 mm).

In some embodiments, the visible light from the light stimulus is transmitted through an infrared (IR)-reflecting mirror in the apparatus so as to be seen by the subject. In some embodiments, the IR-reflecting mirror is inclined towards the illumination panel.

In some embodiments, as a result of illumination on the eye from the illumination source, the light reflected from the eye is transmitted by a means of lens to the IR-reflecting mirror. In some embodiments, the light reflected from the eye comprises infrared light that is transmitted by means of a lens positioned at a predefined distance from the opening. In some embodiments, the reflected light that has been transmitted by the lens including Fresnel lens is reflected by the infrared (IR)-reflecting mirror to an infrared (IR) camera such that an image of the eye being tested is captured. In this regard, the position of the eye being concentric or the angle that is coaxial to the eye may be determined. In some embodiments, readjustment or repeating the steps of the method disclosed herein may be necessary when the eye does not appear concentric. In some embodiments, as previously described, the camera including the IR

camera may include one or more camera lenses. In some embodiments, the IR camera may include one camera lens. In some embodiments, the one or more camera lens is configured to focus the image of the eye. Advantageously, the one or more camera lens may be configured to focus only when the position of the eye is concentric. In such an embodiment, the camera may provide feedback to the user that the positioning of the device is proper. In some embodiments, as described herein, manual adjustment of the camera or camera lens by assessing the image of the eye captured may be implemented.

In some embodiments, the method described above may be suitable for determining the visual field of the eye of the subject. In such an embodiment, the determination of the visual field may be by means of identifying whether the subject is able to see the light stimulus.

In some embodiments, the lens of the device used for determining the visual field test described herein is a flat lens. In some embodiments, the flat lens is a Fresnel lens for focusing the visible light stimulus seen by the eye of the subject. Advantageously, the Fresnel lens may be those commercially available that may be used as is without further modification. In some embodiments, the Fresnel lens may be made of polymeric-based material. The polymer of the polymeric-based material may include poly(methyl methacrylate) (PMMA). In some embodiments, the polymer may be provided in the form of homopolymer, co-polymer or mixture thereof. In some embodiments, the Fresnel lens may have the following technical specifications: index of refraction of from about 0.4 to 1.8 at a range of wavelength from about 350 nm to about 700 nm, flat profile, transparent and diameter of from 45 mm to 55 mm, for example 45 mm, 46 mm, 47 mm, 48 mm, 49 mm, 50 mm, 51 mm, 52 mm, 53 mm, 54 mm, or 55 mm.. It is to be understood that other suitable technical specifications of the Fresnel lens may be used. For instance, lens diameter of more than 55 mm may be used provided that the lighting of the eye from the ring of IR light is sufficiently efficient as bigger ring of IR light will be required. In some embodiments, lens diameter of less than 45 mm may be used provided that a reasonable field of view is achieved.

In some embodiments, the device and the system disclosed herein may be suitable for measuring the extent of peripheral (side) vision of an individual. This in turn will be useful to detect vision problems including blind spots (scotomas) or visual field loss that may be caused by various health conditions such as glaucoma, tumors and strokes.

EXAMPLES

Example 1 – inventive Visual Field Device

Fig. 1 illustrates the process of performing a visual field testing using a testing device 10, according to some embodiments of the present disclosure. A light stimulus from an illumination panel 40 is to be seen by an eye 100 of a subject. Infrared (IR) light from the ring 60 is reflected by the eye 100 towards Fresnel lens 20 having a focal length of about 55 mm. The IR light that has been transmitted by Fresnel lens 20 is then reflected by a hot mirror 30 to IR-camera 50 that will subsequently capture the images of the eye and determine if the eye is concentric. In other words, IR camera 50 fitted with an 8-mm focal length M12 lens is placed at an angle where the image produced by the camera will be coaxial to the eye seen. As can be seen from Fig. 1, the hot mirror 30 is inclined at a predefined angle towards the illumination panel 40. The co-axiality will ensure that the device 10 can be adjusted such that Fresnel lens 20 is concentric to the eye's pupil, which is essential to correct the field of view (FOV). Advantageously, the co-axiality may enable detection of droopy eyelids, which causes a phenomenon called "rim defect" affecting the visual field analysis (VFA) results.

Fig. 2A illustrates implementation of the testing device 10. As can be seen from this drawing, in operation, device 10 housed in a housing 80 is mounted on a support. In this configuration, a system comprising housing 80 and an adjustable support is described. As can be seen, the support may be adjusted in three-dimensional space and may comprise a base 98. The subject undergoing the visual field test can adjust his or her head relative to housing 80 by means of forehead rest 82 and chin rest 84. The height of chin rest 84 may be adjusted by rotating a chin rest height adjuster 86 to position the chin rest 84 higher or lower in vertical direction. Device 10 or housing 80 may be mounted on an adjustable support comprising an adjustment mechanism. The adjustment mechanism may be a knob adjuster 88 such that a user may turn the knob clockwise or anticlockwise to position device 10 or housing 80 higher or lower in vertical direction. A lever 92 may also be provided to allow switching the opening for the eyes to be examined. For instance, the right side opening will allow right eye to be tested and the left side opening will allow left eye of the user to be tested. While lever 92 is located at the base 98 of the support as shown in Fig. 2A, it is understood that lever 92 may be positioned at any position in the proximity of the user for ease of adjustment. Additionally, the system may comprise one or more further adjustment mechanisms. In an exemplary embodiment, the one or more further adjustment mechanisms comprise a second adjustment mechanism and a third adjustment mechanism. The second adjustment mechanism may be a knob 94 that enables forward or backward adjustment relative to the base 98 of the support. In

some embodiments, the forward or backward adjustment may be fine forward or backward adjustment. In an exemplary embodiment, the third adjustment mechanism may be a knob 96 that enables lateral adjustment (right or left) relative to the base 98 of the support. In some embodiments, the lateral adjustment may be a fine lateral adjustment.

As illustrated at least in Figs. 2A and 2B, the user may interact with device 10 via a user interface for example a response button 86 shown in the drawings. As the visual field test is progressing, the user interacts with the device via the response button 86, and the outcome of the test may be directly displayed to the user or sent to a healthcare professional for further analysis. In some embodiments, the outcome of the test disclosed herein may depend on the reaction time of the user and accuracy. In some embodiments, based on the reaction time and accuracy, a map of the patient's visual field may be generated to provide information and insight of any blind spots or areas with reduced vision.

The device disclosed herein may further comprise one or more processor (in the form of computer for example microcomputer). The processor may control the operation of the device including stimulants to be displayed in the illumination panel or screen. The processor or the computer may also control the IR camera used for recording and monitoring the eye being tested. As illustrated in Fig. 3, the components of the device are interacting one with the others. The system disclosed herein including the testing device may be powered by a single power supply of 5.3 V, 25 watts.

The microcomputer may be connected to a router where any browser enabled device with proper credentials may connect to the microcomputer and access the device's web interface. The user may obtain a feedback from the IR camera through the web interface to position his or her eye on the device, enter his or her particulars and administration of the test.

Example 2 – Correlating the display of the inventive Visual Field Device and HFA

LCDs obtained from suppliers typically provide datasheets that do not go in depth detailing the screen's luminance levels with respect to the software controllable levels. In this regard, the only parameters available from the datasheet, that may help in determining the dynamic range of the system disclosed herein is the highest luminance the screen can produce, which may not be accurate representation of the screen's luminance level. For this reason, measuring every grayscale level of the LCD screen using a spectroradiometer is essential. Advantageously, the method disclosed in the current disclosure solves the above drawback.

In some embodiments, luminance level including highest luminance level of the panel (for example LCD) may be determined using spectroradiometer. In some embodiments, other

suitable means for determining the luminance level may be used. It is to be appreciated that a panel or screen consists programmatically, RGB (red, green, blue) values for example 1R,1G,1B equates to a certain shade of grey. Accordingly, there may be 254 shades of grey an LCD screen can produce. In some embodiments, programmatically, the screen may go from grayscale level 0 (black) to 255 (brightest white). In some embodiments, the measured values using a spectroradiometer follow a linear trend. In some embodiments, the measured values using a spectroradiometer follow a non-linear curve.

In some embodiments, due to discrete grayscale levels, selecting a suitable background illumination is important such that a "calibration" or conversion process is performed to correlate the discrete grayscale levels closely to HFA's dB. All levels producible by the LCD by using equations (iii) and (iv) were converted to HFA's dB scale. Following this conversion, it was determined that the best suited background illumination is 13.85 asb. For the cases where the values were not exactly equivalent to HFA's dB, the closest value to represent that level was used. As an example, for dB levels 33 and 34, they share a level 28 on grayscale, which corresponds to 33.9 dB. Similarly, level 29 on grayscale, which corresponds to 31.4 dB is shared by HFA's dB levels 31 and 32.

From HFA's dB levels 30 to 19, they are approximately 99% accurate. In some embodiments, the remaining levels are exact and do not face quantization effect.

Example 3 – Performance of the inventive Visual Field Device

The performance of the device disclosed herein was assessed and benchmarked against the Humphrey's visual field analyzer (Zeiss) in the detection of glaucomatous visual field defects. A case-control clinical study involved 30 normal volunteers (60 eyes) and 40 participants suffering from glaucoma (80 eyes). All participants underwent the tests using both HFA and the device disclosed herein on the same day. The subjective responses on the device was converted into a scaled heat-map display and the results were compared with the grey-scale display of the values of HFA. The comparison suggests the Pearson correlation coefficient analysis (R^2) between the two devices of 0.78. Additionally, the Bland Altman plot showing the mean deviation suggests that the results obtained from using the device disclosed herein agree well with the standard device (HFA).

The block diagrams included in the current disclosure illustrate architecture, functionality or an operation of possible implementations of systems, methods and computer program products according to various embodiments of the present disclosed subject matter. In this regard, each block in the flowchart or block diagrams may represent a module, segment,

or portion of program code, which comprises one or more executable instructions for implementing the specified logical function(s). It should also be noted that, in some alternative implementations, illustrated or described operations may occur in a different order or in combination or as concurrent operations instead of sequential operations to achieve the same or equivalent effect.

The corresponding structures, materials, acts, and equivalents of all means or step plus function elements in the claims below are intended to include any structure, material, or act for performing the function in combination with other claimed elements as specifically claimed.

As used herein, the singular forms "a", "an" and "the" are intended to include the plural forms as well, unless the context clearly indicates otherwise. It will be further understood that the terms "comprising", “including” and/or "having" and other conjugations of these terms, when used in this specification, specify the presence of stated features, integers, steps, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, integers, steps, operations, elements, components, and/or groups thereof.

The terminology used herein should not be understood as limiting, unless otherwise specified, and is for the purpose of describing particular embodiments only and is not intended to be limiting of the disclosed subject matter. While certain embodiments of the disclosed subject matter have been illustrated and described, it will be clear that the disclosure is not limited to the embodiments described herein. Numerous modifications, changes, variations, substitutions and equivalents are not precluded.

It will be appreciated by persons skilled in the art that the present invention is not limited to what has been particularly shown and described hereinabove. Rather the scope of the present invention is defined only by the claims, which follow.

CLAIMS

1. A visual field testing apparatus comprising:

an illumination panel for generating light stimulus towards an opening, said light stimulus comprising light having wavelength from visible to infrared region; and

an optical module, said optical module comprising:

a lens positioned at a predefined distance from the opening; and

an infrared (IR)-reflecting mirror positioned between the illumination panel and the lens, said IR-reflecting mirror is inclined towards the illumination panel and allows visible light stimulus from the illumination panel to an eye of a subject; and

an infrared (IR) camera configured to capture an image of the eye reflected by the IR-reflecting mirror that has been focused by a camera lens.

2. The apparatus according to claim 1, wherein said illumination panel is positioned at a distal end of the device and said opening is located at a proximal end of the device.

3. The apparatus according to claim 1 or 2, wherein said IR camera is positioned such that the eye in the image captured by the IR camera is concentric.

4. The apparatus according to any one of the preceding claims, wherein said lens is a flat lens.

5. The apparatus according to claim 4, wherein said flat lens is a Fresnel lens for focusing the visible light stimulus seen by the eye of the subject.

6. The apparatus according to any one of the preceding claims, further comprising a plurality of illumination source positioned at the opening of the apparatus.

7. The apparatus according to claim 6, wherein the plurality of illumination source is provided on a ring.

8. The apparatus according to claim 7, wherein the plurality of illumination source comprising 4, 6, 8 or 10 illumination sources disposed on the ring.

9. The apparatus according to any one of claims 6 to 8, wherein the plurality of illumination source comprising one or more infrared light emitting diodes (IR LEDs).

10. The apparatus according to any one of the preceding claims, wherein the IR-reflecting mirror is inclined at a predefined angle of about 40^{o} to 70^{o}, preferably about 55^{o}.

11. The apparatus according to any one of the preceding claims, wherein the illumination panel, optical module and IR camera are located within a housing.

12. The apparatus according to claim 11, further comprising a positioning mechanism connected to the housing to allow a user to adjust the position of said apparatus.

13. A method comprising the steps of:

positioning an eye of a subject on an opening at proximal end of a testing apparatus;

directing light stimulus generated by an illumination panel towards said opening, said light stimulus comprising light having wavelength from visible to infrared region;

transmitting visible light from the light stimulus through an infrared (IR)-reflecting mirror in the apparatus to be seen by the eye of the subject, said IR-reflecting mirror is inclined towards the illumination panel;

focusing the visible light stimulus seen by the eye of the subject by means of a lens positioned at a predefined distance from the opening; and

reflecting the infrared light from the infrared (IR)-reflecting mirror to an infrared (IR) camera such that an image of the eye that has been focused by a camera lens is captured.

14. The method according to claim 13, further comprising determining the visual field of the eye of the subject by means of identifying whether the subject is able to see the light stimulus.

15. The method according to claim 14 or 15, wherein said lens in the apparatus is a flat lens.

16. The method according to claim 15, wherein said flat lens is a Fresnel lens for focusing the visible light stimulus seen by the eye of the subject.