AN EYE TESTING DEVICE AND METHODS OF USING THE SAME

TECHNICAL FIELD

The present disclosure generally relates to an eye testing device and methods of using the same. In particular, the eye testing device is used to measure the refractive errors, visual acuity and combination thereof.

BACKGROUND

Refraction and visual acuity tests are the most common and universal tests to determine the corrective power needed for an eye and the visual function of the eye, respectively. It is also acknowledged that these tests are resource consuming as they require skilled labor, for example an optometrist and a considerable amount of space in a clinic or hospital. Large amounts of space and lenses are usually needed to conduct a refraction or visual acuity test in tertiary settings such as hospitals. For acuity test, a distance of 6 meters from Snellen chart is usually required. That space could be better used to reduce long waiting times a patient may experience to see a doctor. This can be in the form of converting the room into multiple consultation rooms for more doctors to see patients or for conducting tests that have been bottlenecks in the whole patient journey.

In view of the above challenges, therefore there is a need to provide an eye testing device that allows the refraction or visual acuity test to be conducted in a smaller amount of space.

SUMMARY

There is provided an eye testing device to measure refractive errors or visual acuity, said device comprising a screen to display one or more characters, symbols or predefined patterns, the screen being tilted at a predefined angle, an optical module for demagnifying the displayed one or more characters or symbols and for defining an optical path, said module comprising a first mirror positioned in substantially vertical position to reflect the demagnified one or more characters or symbols, a second mirror to receive the reflected one or more characters, symbols or predefined patterns from the first mirror and to reflect further demagnified one or more characters or symbols to an eye of a subject through a first lens, said first lens being positioned between the second mirror and the eye of the subject. According to some embodiments of the present disclosure, the predefined angle is in a range between 10^{o} to 45^{o}.

According to some embodiments of the disclosure, the first mirror may be a plane mirror. According to some embodiments of the disclosure, the second mirror may be a convex mirror. Optionally, the second mirror may be tilted at a second predefined angle relative to the first mirror. The second predefined angle may be in a range between 8° to 25°, preferably 13°. According to some embodiments of the disclosure, the lens may be a positive or convex lens. Optionally, said optical module may further comprise a second lens placed between the second mirror and the first lens. The second lens may be a negative or concave lens.

According to some embodiments of the disclosure, the device may be a self-administered device. Optionally, said screen and optical module are placed within a housing. Further optionally, said housing may be mounted on a positioning arm.

According to some embodiments of the disclosure, the device may further comprise an opening at a proximal section of the device, said opening is configured to engage with an eyepiece. Optionally, the device may further comprise a camera.

Further, there is provided a method to measure refractive errors or visual acuity using a device, said device comprising a screen to display one or more characters, symbols or predefined patterns, the screen being tilted at a predefined angle, an optical module for demagnifying the displayed one or more characters, symbols or predefined patterns and for defining an optical path, said module comprising a first mirror positioned in substantially vertical position to reflect the demagnified one or more characters, symbols or predefined patterns, a second mirror to receive the reflected one or more characters, symbols or predefined patterns from the first mirror and to reflect further demagnified one or more characters, symbols or predefined patterns to an eye of a subject through a first lens, said first lens being positioned between the second mirror and the eye of the subject, said method comprising the steps of positioning the eye of the subject on an opening at proximal section of said device and directing the optical path defined by the optical module of said device towards the eye of the subject to display demagnified one or more characters, symbols or predefined patterns, wherein said one or more characters, symbols or predefined patterns are to be read by the subject. The opening may be configured to engage with an eyepiece.

Optionally, the method may further comprise determining the refractive errors or visual acuity by means of identifying whether the subject is able to read the one or more characters, symbols or predefined patterns. Optionally, determining the refractive errors may comprise adjusting a user interface in the device such that the subject is able to identify the predefined

pattern displayed on the screen, and wherein the number of adjusting steps required is indicative of the power of refraction.

Optionally, determining the refractive errors may further comprise rotating the eyepiece to a first rotation angle, adjusting the user interface defined by a first number of adjusting steps required, such that the subject is able to identify a first predefined pattern displayed on the screen, rotating the eyepiece to a second rotation angle, said second rotation angle is different from the first rotation angle, adjusting the user interface defined by a second number of adjusting steps required, such that the subject is able to identify a second predefined pattern displayed on the screen, rotating the eyepiece to a third rotation angle, said third rotation angle is different from the first rotation angle and the second rotation angle, and adjusting the user interface defined by a third number of adjusting steps required, such that the subject is able to identify a third predefined pattern displayed on the screen and wherein the power of astigmatism is defined by subtracting the most number of adjusting steps required with the least number of adjusting steps required.

Optionally, the method may further comprise rotating the eyepiece to a fourth rotation angle, said fourth rotation angle is different from the first rotation angle, the second rotation angle and the third rotation angle, adjusting the user interface defined by a fourth number of adjusting steps required, such that the subject is able to identify a fourth predefined pattern displayed on the screen and wherein the power of astigmatism is defined by subtracting the most number of adjusting steps required with the least number of adjusting steps required.

According to some embodiments of the disclosure, the least number of adjusting steps required may be indicative of myopic power.

According to some embodiments of the disclosure, the rotation angle at which the most number of adjusting steps is required may be indicative of the angle of astigmatism.

According to some embodiments of the disclosure, said eyepiece may be a circular eyepiece comprising two holes. Optionally, said two holes may be equally spaced apart with respect to the center of the eyepiece. According to some embodiments of the disclosure, before the first rotation, said two holes may be equally spaced apart with respect to the center of the eyepiece in vertical direction.

According to some embodiments of the disclosure, each of the adjusting steps required may represent about -0.5 diopters defined through calibration. Optionally, said calibration may be undertaken using a camera.

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 illustrates a schematic diagram of the optical path defined in the eye testing device, in accordance with some embodiments of the present disclosure;

Fig. 2 is a perspective view of the device showing the optical components thereof, in accordance with some embodiments of the present disclosure;

Fig. 3 illustrates the implementation of the system including the device, in accordance with some embodiments of the present disclosure;

Fig. 4 is a block diagram describing the interconnectivity between the device and other components of the system, in accordance with some embodiments of the present disclosure;

Fig. 5 is a perspective view of the rotatable double pinhole eyepiece, in accordance with some embodiments of the present disclosure;

Fig. 6a is the pattern seen in the screen for subjects with refractive error;

Fig. 6b is the pattern seen in the subjects without refractive errors, in accordance with some embodiments of the present disclosure;

Fig. 6c, (i) and (ii) illustrate the lines converging process during the measurements of refractive errors, in accordance with some embodiments of the present disclosure;

Fig. 6c, (iii) and (iv) illustrate the lines diverging process during the measurements of refractive errors, in accordance with some embodiments of the present disclosure;

Fig. 6c, (v) illustrates the predefined pattern seen after the lines diverging or converging process during the measurements of refractive errors, in accordance with some embodiments of the present disclosure; and

Fig. 7 illustrates the front side of the rotatable double pinhole eyepiece and the corresponding pattern seen at the respective rotation angle, 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 device to measure refractive errors. In some embodiments, the same device may also be used to measure the visual acuity. Accordingly, in some embodiments, said device may be configured to measure refractive errors and visual acuity. In some embodiments, said device comprises a screen to display one or more characters or symbols and an optical module for demagnifying the displayed one or more characters or symbols. In some embodiments, said device includes a screen to display one or more characters or symbols as described above and an optical module for demagnifying the displayed one or more characters or symbols and for defining an optical path. In some embodiments, the screen may further comprise predefined patterns suitable when the device is used for measuring the refractive errors including the power of myopia. In some embodiments, when the device is used to measure the visual acuity, said screen comprises optotypes containing figures (or numbers) or letters of different sizes. In some embodiments, said screen comprises a Snellen chart. In some embodiments, said screen comprises a tumbling E chart or symbols for the illiterate. In some embodiments, said screen comprises Landolt C or broken ring. In some embodiments, said screen comprises pediatric symbols. In some embodiments, said screen comprises standardized Cyrillic letters in the Golovin–Sivtsev table. It is to be understood that other characters or symbols suitable for the eye testing may be used.

In a typical visual acuity testing, a Snellen chart is used and the screen showing the characters or symbols is placed at about 6 meters or 20 feet from the subject. A 6/6 or 20/20 vision is considered normal. Accordingly, in some embodiments of the present disclosure, the optical module is configured to demagnify the screen displaying the optotypes to match the Snellen chart's 6/60 (the equivalent of 50 arc min). In such an embodiment, the degree of demagnification may be calculated using equation (i):

$$\frac{\text{screen height}}{\tan(arc\text{min}) * \text{screen distance}}$$

In some embodiments, for a screen height of about 68 mm and a screen distance of about 178 mm away from the eye, the degree of demagnification is about 26.3 times. It is to be appreciated that the screen height and screen distance may be adjusted accordingly to obtain other desired degree of demagnification. Further, it is understood that the screen distance above may also be considered as the distance of the optical path.

As one may appreciate, when the device disclosed in the present application is in use, the device may fold or reduce the distance of the optical path typically required for conducting the visual acuity test.

In some embodiments, the screen may be tilted at a predefined angle such that the one or more characters, symbols or predefined pattern displayed on the screen may be projected to the optical module. In some embodiments, said optical module may include a first mirror positioned in substantially vertical position to reflect the demagnified one or more characters or symbols from the screen. It is to be understood that the predefined angle is with respect to the vertical position. In some embodiments, the predefined angle may be in a range between about 10^{o} to 55^{o} for example about 10^{o}, about 15^{o}, about 20^{o}, about 25^{o}, about 30^{o}, about 35^{o}, about 40^{o}, about 45^{o}, about 50^{o}, or about 55^{o}. In some embodiments, the first mirror may be a plane or flat mirror. Accordingly, as the screen is tilted at the above predefined angle with respect to the plane mirror, the one or more characters or symbols reflected by the plane mirror may be demagnified.

In some embodiments, said optical module may further comprise a second mirror to receive the reflected one or more characters or symbols from the first mirror. In some embodiments, said second mirror is configured to reflect further demagnified one or more characters or symbols to an eye of a subject. In some embodiments, the second mirror is a convex mirror. In some embodiments, the second mirror is tilted at a second predefined angle

relative to the first mirror. In some embodiments, the convex mirror is tilted at a second predefined angle relative to the first mirror. In some embodiments, the second predefined angle may be in a range between about 5º to about 30º, for example about 5º, about 8º, about 10º, about 13º, about 16º, about 20º, about 25º, or about 30º. In some embodiments, the second predefined angle is preferably 13º.

In some embodiments, the one or more characters or symbols are reflected from the second mirror as defined by the optical path. In some embodiments, the second mirror is configured to further demagnify one or more characters or symbols to an eye of a subject through a first lens. In some embodiments, said first lens may be positioned between the second mirror and the eye of the subject. In some embodiments, the first lens is a positive or convex lens. In some embodiments, the first lens or convex lens is positioned in a substantially vertical position to allow the optical path to be transmitted to the eye.

In some embodiments, the optical module may further comprise a second lens placed between the second mirror and the first lens. In some embodiments, the second lens is a negative or concave lens. Accordingly, in some embodiments, the optical module of the device disclosed herein may further comprise a concave lens placed between the convex mirror and the positive lens. In some embodiments the second lens or concave lens is positioned in a substantially vertical position.

In some embodiments, to minimize or substantially reduce barrel distortion caused by the convex mirror, the one or more characters or symbols displayed on the screen comprise a pincushion distortion.

In some embodiments, the first lens and the second lens, each may be mounted on a cage. Accordingly, the first lens may be mounted on the first cage and the second lens may be mounted on the second cage. In some embodiments, dimensions of the first cage and second cage are identical or different. More importantly, dimensions of the first cage and second cage may be adjusted or customized accordingly. In some embodiments, the lens may be held in its position in the cage by one or more fastening mechanisms or fastener including bracket. In some embodiments, said bracket may be cage mounting bracket. In some embodiments, the cage may be held by two or more assembly rods positioned at the lower section of the cage. In some embodiments, the device may further comprise a cage assembly, said cage assembly comprising one or more cage for holding each of the lenses, wherein each of the cage comprising one or more fastening mechanism and wherein the one or more cages are held by two or more assembly rods positioned at the lower section of the one or more cages.

In some embodiments, the screen and the optical module of the device as described above may be housed or substantially housed in a housing. In such an embodiment, said screen and optical module may therefore be placed within said housing. Accordingly, when the screen and optical module are placed within the housing, it is to be understood that the first mirror, the second mirror, the first lens and the second lens are found within the housing. In some embodiments, the screen, the flat mirror, the convex mirror, the convex lens and the concave lens are positioned within the housing.

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 refractive errors measurement or visual acuity test without assistance of a skilled labor (for example a nurse or ophthalmologist). In some embodiments, the housing may be mounted on a positioning arm to facilitate the adjustment of the device. In some embodiments, any other suitable adjusting mechanism to allow adjustment of the device or the housing in 3D space may be used. In some embodiments, the device may be mounted on a mechanism comprising one or more platforms, where each of the one or more platforms comprises a guide rail for adjustment in x, y and z axis. In some embodiments, the device may further comprise a guide channel attached to the housing allowing the positioning of the device in a given axis or direction as the guide rail of the adjustment mechanism mates the guide channel of the housing. In such an embodiment, the device or the housing is said to be slidably attached to the one or more platforms. As one may appreciate, the adjustment mechanism allows the housing or the device to be positioned at a plurality of predetermined positions. In some embodiments, a fastening mechanism may be coupled to the adjustment mechanism above such that when a predetermined position is attained, the housing can be secured at that position to avoid any incidental adjustment. In some embodiments, the fastening mechanism may include but not limited to screws, snap-fits and threads.

In some embodiments, the device disclosed herein may further comprise an opening at a proximal section of the device, said opening is configured to engage with an eyepiece. In some embodiments, said eyepiece may be provided in a substantially circular shape. When the eyepiece is a circular eyepiece, said eyepiece may comprise two holes equally spaced apart with respect to the circular eyepiece.

In some embodiments, a calibration of the device may be required. When the calibration is necessary, the calibration may be performed using a camera. The type of the camera is not limited and therefore any suitable camera may be used. Accordingly, in some embodiments, the device disclosed may further comprise a camera.

In some embodiments, when the calibration step is required, the camera may be configured to image the Snellen chart at a distance where a typical visual acuity test is performed. Subsequently, the same camera with the same settings may be used to image the optical module of the device disclosed herein. In this manner, the magnification of the device disclosed here may advantageously be adjusted such that the one or more characters or symbols shown on the screen is of the same size as seen in the image taken from the Snellen chart. Further advantageously, the calibration procedure may provide additional information including inaccurate position of the components in the device, which may be rectified by virtue of the calibration procedure.

In some embodiments, the device may be used in conjunction with 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

There is provided a method to measure refractive errors or visual acuity using a device as disclosed in the present disclosure. In some embodiments, said device comprising:

a screen to display one or more characters, symbols or predefined patterns, the screen being tilted at a predefined angle;

an optical module for demagnifying the displayed one or more characters, symbols or predefined patterns and for defining an optical path, said module comprising:

a first mirror positioned in substantially vertical position to reflect the demagnified one or more characters, symbols or predefined patterns; and

a second mirror to receive the reflected one or more characters, symbols or predefined patterns from the first mirror and to reflect further demagnified one or more characters, symbols or predefined patterns to an eye of a subject through a first lens, said first lens being positioned between the second mirror and the eye of the subject.

In some embodiments, the method comprising the steps of:

positioning the eye of the subject on an opening at proximal section of said device;

directing the optical path defined by the optical module of said device towards the eye of the subject to display demagnified one or more characters, symbols or predefined patterns, wherein said one or more characters, symbols or predefined patterns are to be read by the subject.

In some embodiments, there is provided a method to measure refractive errors or visual acuity using a device, said device comprising:

a screen to display one or more characters, symbols or predefined patterns, the screen being tilted at a predefined angle;

an optical module for demagnifying the displayed one or more characters, symbols or predefined patterns and for defining an optical path, said module comprising:

a first mirror positioned in substantially vertical position to reflect the demagnified one or more characters, symbols or predefined patterns;

a second mirror to receive the reflected one or more characters, symbols or predefined patterns from the first mirror and to reflect further demagnified one or more characters, symbols or predefined patterns to an eye of a subject through a first lens, said first lens being positioned between the second mirror and the eye of the subject;

said method comprising the steps of:

positioning the eye of the subject on an opening at proximal section of said device;

directing the optical path defined by the optical module of said device towards the eye of the subject to display demagnified one or more characters, symbols or predefined patterns, wherein said one or more characters, symbols or predefined patterns are to be read by the subject.

In some embodiments, the method further comprises determining the refractive errors or visual acuity by means of identifying whether the subject is able to read the one or more characters, symbols or predefined patterns. It is to be appreciated that when the subject is able to read or identify the character, symbol or predefined pattern, the refractive errors or visual acuity of the subject may be estimated by said device.

In some embodiments, to determine the refractive errors, a user interface in the device may be adjusted such that the subject is able to identify the predefined pattern displayed on the screen, and wherein the number of adjusting steps required is indicative of the power of refraction. In some embodiments, the user interface may be indications displayed on a display screen in communication with a processor. In some embodiments, the user interface may be provided as keypad or joystick or even voice recognition sensor, in communication with the processor. It is to be appreciated that the user interface may allow interaction between a user or a subject and the device disclosed herein such that the subject may perform the eye testing exercise independently or with minimal assistance.

In some embodiments, the opening of the device previously mentioned may be configured to engage with an eyepiece. In some embodiments, said eyepiece is a viewing eyepiece. In some embodiments, the viewing eyepiece may be substantially circular viewing eyepiece although other suitable geometry may also be used. In such an embodiment, the device may be suitable for measuring the visual acuity. In some embodiments, said eyepiece is a circular eyepiece comprising two holes. In such an embodiment, the device may be suitable for measuring the refractive errors.

In some embodiments, for each of the viewing eyepiece and the circular eyepiece comprising two holes, the eyepiece comprises a substantially horizontal and encircling side wall. In some embodiments, the side wall may be a flat or tapering side wall. The side wall defines an opening of the eyepiece at a proximal end of said eyepiece. In some embodiments, the circular eyepiece having two holes may comprise the two holes positioned on a plane located at or near the proximal end of the eyepiece, wherein said plane is configured to substantially cover the opening of the eyepiece.

While other geometry of the eyepiece may be considered, the circular eyepiece is preferred. In some embodiments, the eyepiece further comprises a plurality of markings to define the angle of rotation of the eyepiece. In some embodiments, the markings may be located on the side wall at or near the proximal end of the eyepiece. In some embodiments, the eyepiece may comprise a plurality of secondary markings positioned at the peripheral portion of the plane configured to substantially cover the opening of the eyepiece. In some embodiments, to match the encircling geometry of the side wall, the plane may be substantially circular. In some embodiments, said plane may serve as a cover. In some embodiments, the eyepiece comprises two holes that are equally spaced apart with respect to the center of the eyepiece. In some embodiments, the center of the eyepiece refers to the center of circular cover.

In an alternative embodiment, the eyepiece may comprise a proximal portion configured to contact with the eye of the subject or part thereof, and a distal portion connected or attached to the housing of the device. In such an embodiment, the distal portion may be mounted on the device and replaced when necessary. In some embodiments, the distal portion comprises a flat or tapering side wall. In some embodiments, the encircling side wall defines opening of the distal portion. In some embodiments, the proximal portion comprises encircling side wall having a first end and a second end, said second end is opposite of the first end. In some embodiments, the encircling side wall defines the opening of the proximal portion. In some embodiments, the second end of the proximal portion is substantially enclosed by a plane where the two holes are located. In some embodiments, the second end of the proximal portion

is configured to be connected with the distal portion such that the proximal portion of the eyepiece can be rotated with respect to the distal portion. In such an embodiment, it is understood that the distal portion may be fixed or stationary during operation of the device.

In some embodiments, there is provided a system to measure the refractive errors or the visual acuity, said system comprises the device as disclosed herein. In some embodiments, said system further comprises a user interface as previously described. In some embodiments, said system further comprises circuitry coupled to a controller or a signal processing unit. In some embodiments, the controller or signal processing unit may be coupled to a data interface, a memory, LCD display, and a charging module. In some embodiments, the signal processing unit may comprise a processor for performing signal processing and executing a program part of the measurements of refractive errors or visual acuity. In some embodiments, the controller or signal processing unit may include a communication module and interface with circuitry for relaying data between the device and any other computing and/or storage device including PC or Cloud Data Center via any suitable wired and/or wireless communication protocols (e.g., Wi-Fi, Bluetooth, cellular communication).

In some embodiments, the processor (e.g., MCU/DSP unit) may include one or more processing units, e.g. of one or more computers. Processor may be configured to operate in accordance with programmed instructions stored in SDRAM and/or NAND Flash or any other suitable storage device and/or memory. In operation, processor may execute a method for measuring the refractive errors and/ or visual acuity in an eye of a subject.

Accordingly, to determine the refractive errors, after directing the optical path towards the eye of the subject, the subject may interact with the device in the following manners:

rotating the eyepiece to a first rotation angle;

adjusting the user interface defined by a first number of adjusting steps required, such that the subject is able to identify a first predefined pattern displayed on the screen;

rotating the eyepiece to a second rotation angle, said second rotation angle is different from the first rotation angle;

adjusting the user interface defined by a second number of adjusting steps required, such that the subject is able to identify a second predefined pattern displayed on the screen;

rotating the eyepiece to a third rotation angle, said third rotation angle is different from the first rotation angle and the second rotation angle; and

adjusting the user interface defined by a third number of adjusting steps required, such that the subject is able to identify a third predefined pattern displayed on the screen;

For clarity, each of the rotation angles above may be predefined by a health professional including an ophthalmologist. The first, second and third rotation angles may be selected from 0 or 180º, 45º, 90º, and 135º. In some embodiments, the three different rotation angles may be 0 or 180º, 45º and 135º or 0 or 180º, 45º and 90º. It is also to be understood that each rotation angle may display a different predefined pattern.

In some embodiments, the further rotations and adjustment steps following the adjustment steps after the third rotation may be undertaken. In some embodiments, following the adjustment steps after the third rotation, the method further comprises

rotating the eyepiece to a fourth rotation angle, said fourth rotation angle is different from the first rotation angle, the second rotation angle and the third rotation angle;

adjusting the user interface defined by a fourth number of adjusting steps required, such that the subject is able to identify a fourth predefined pattern displayed on the screen; and

wherein the power of astigmatism is defined by subtracting the most number of adjusting steps required with the least number of adjusting steps required.

In some embodiments, the further rotations and adjustment steps following the adjustment steps after the fourth rotation may be undertaken.

In some embodiments, adjustment of the user interface may be defined by the number of steps required till the user or subject is able to read or identify the predefined pattern. In some embodiments, the predefined pattern may comprise one or more lines and one or more dots. In some embodiments, the predefined pattern may comprise a single dot disposed substantially in equidistance between two horizontal lines. In some embodiments, when a subject has a refractive error, patterns other than the predefined pattern may be seen. The objective of the adjustment steps is to merge distortions seen by the subject having the refractive error. The adjustment step may include asking the subject if he or she can identify the predefined pattern or if distortions are not seen. If the distortion is seen, the subject may adjust by choosing to diverge or converge the lines. Each of the adjustments required until the subject can identify the predefined pattern may be counted as a number of adjustment step. In some embodiments, each of the number of the adjustment step may be defined by a calibration with a camera. In some embodiments, any suitable camera including infrared or thermal camera can be used. In some embodiments, each of the number of the adjustment step may be defined as -0.5 diopters. In such an embodiment, at a given rotation angle, one adjustment step represents -0.5 diopters, two adjustment steps represent -1.0 diopters, three adjustment steps represent -1.5 diopters and so forth. It is to be understood that based on the calibration, each of the adjustment steps may represent other values than -0.5 diopters. In some embodiments, the

least number of adjusting steps required is indicative of myopic power. In some embodiments, the most number of adjusting steps required represents axis of meridian. In some embodiments, the number of adjustment steps required at a given rotation angle is indicative of power of refraction on that axis of meridian.

In some embodiments, the power of astigmatism may be defined by subtracting the most number of adjusting steps required with the least number of adjusting steps required. In some embodiments, the rotation angle at which the most number of adjusting steps required is indicative of the angle of astigmatism.

In some embodiments, during the measurement of the refractive errors, before the first rotation of the circular eyepiece, said two holes are equally spaced apart with respect to the center of the eyepiece in vertical direction.

EXAMPLES

Example 1 – Visual Acuity Test

Fig. 1 illustrates the optical design of the eye testing device disclosed in the present disclosure. As mentioned above, the device can be used to measure refractive errors and visual acuity. Device 100 includes optical components that substantially shortens the optical path 170 of 6 m-Snellen chart distance to approximately 20 cm by folding the distance using mirrors (120, 130) using the demagnifying chart shown on the screen 110 that is comparable to the size seen from a 6 m-Snellen chart. As can be seen from Fig. 1, device 100 includes optical components that demagnify screen 110 displaying optotypes to match the Snellen chart's 6/60 that is 50 arcmin to be seen or read by the eye 150 of a subject. Device 100 includes a flat mirror 120 and a convex mirror 130 that is tilted about 13^{o} with respect to vertical axis. Device 100 also includes negative lens 160 and positive lens 140. This is to ensure that the optical path is folded to meet a small footprint of 178 x 90 x 128 mm while maintaining the lowest possible distortion such the distortion is unnoticeable to the user.

Negative lens 160 and positive lens 140 are held by adjustable lens mount that resembles a cage. For clarity, negative lens 160 is held by a cage 162 and positive lens 140 is held by a cage 142 as can be seen from Fig. 2. The flat mirror 120 is being supported by a cage 122. The three cages 122, 142, and 162 are mounted or held by two assembly rods 180.

Distortion by convex mirror 130 is substantially reduced or eliminated by transforming the image, character or symbol on the screen 110 to have a pincushion distortion. The device 100 is initially calibrated using a camera (not shown) and imaging the Snellen chart at a

distance where a normal visual acuity is normally conducted. Subsequently, the same camera with the same settings was used to image the optical system of device 100. The magnification of device 100 can be slightly adjusted so that it is of the same size as seen in the image taken from the Snellen chart earlier. Calibration will ensure that it is still possible for corrective action in case the device is not accurately positioned.

Fig. 3 illustrates how device 100 is being implemented. Optical components described earlier are housed in device 100. As can be seen, device 100, together with user interface 400 comprising a touch screen 420, barcode scanner 440 and a printer 460. The barcode scanner 440 is for scanning the identity of the user and a thermal printer 460 is for printing the results of the test. The system may include a positioning arm 200 such that device 100 can be adjusted so that eyepiece 300 located at the proximal opening of device 100 can receive eye of the subject to perform the test.

Interconnectivity of the various components of the device and system is described in Fig. 4. The user can interact with the device via a user interface (touchscreen, keypad or voice recorded or sensor). A set of instructions will be visible on the touchscreen to aid the user in self-administering the test. The instructions include choosing the language, entering or scanning identification of the user, selecting the eye test, and specific instructions for visual acuity test. During the visual acuity test, the user can respond in several ways including by using keypad, touchscreen or by speaking out the numbers seen on screen. Interactions between the device and the user include the system asking the user if the user is able to read or identify the optotypes shown on the screen and subsequent instructions.

About 20 patients and volunteers were enrolled in the study. Each individual underwent visual acuity testing of both eyes with manual Snellen chart tested at 6 m from the subject and the device described here, respectively. The results revealed the mean difference of the two tests was clinically insignificant at -0.03. Additionally, the Pearson correlation coefficient was approximately 0.93 and the Bland Altman plot suggests that most of the test measurements were within 1.96 standard deviation of the mean difference.

Example 2 – Refractive Errors Test

The same device described in Example 1 can be used to measure the refractive errors. For this purpose, the viewing eyepiece is replaced by a rotatable double pinhole eyepiece (see Fig. 5). The device consisting of the rotatable double pinhole eyepiece can be used to measure the refraction of an eye by merging distortions seen by the subject using the double pinhole.

Fig. 6a illustrates the pattern seen by a subject having refractive errors whereas Fig. 6b illustrates the pattern seen by a subject with no refractive errors. Similar as the device described in Example 1, the user can interact with the device by means of a user interface (for example keypad). Specifically, the user can press a button so that after adjustment steps, the predefined pattern such as the one shown in Fig. 6c(v) can be seen. The adjustment may involve pressing a button to converge the lines shown in Figs. 6c(i)-(ii) or another button to diverge the lines as shown in Figs. 6c(iii)-(iv). When the two middle (or inner) lines converged (see Fig. 6c(v)), a third button can be pressed for confirmation that the lines are merged.

The above adjustment process or "merging lines" process is repeated for four different angles for example 0 or 180º, 45º, 90º and 135º. Fig. 7 illustrates this process, showing the front view of the rotatable double pinhole eyepiece with its corresponding rotating angles. The merging lines process can also be repeated for five or six different angles, for example 0 or 180º, 30º, 60º, 90º, 120º, and 150º. Based on the adjustment steps required, the angle that returns the most steps needed (highest power) to merge or converge two lines is the axis meridian. The least number of steps required (lowest power) to merge or converge two lines is indicative of myopic power. The power of astigmatism can be determined by subtracting the highest power with the lowest power. The powers corresponding to the numbers of adjustment steps can be determined and calibrated using a camera system. The camera can be simulated using the lenses that are part of the device. In an exemplary embodiment, the calibration using the camera is adjusted such that each step of adjustment represents -0.5 diopters. Accordingly, in an illustrative example, where the adjustments are performed at four different angles 0 or 180º, 45º, 90º and 135º, each being represented as first, second, third and fourth rotations, respectively. The number of adjustment steps required for the first, second, third and fourth rotations are 4 steps (least), 5 steps, 6 steps (most) and 5 steps, respectively with each adjustment step representing -0.5 diopters (based on the calibration using the camera system). It can be determined that the power of myopia is -2.0 diopters with astigmatism at 180º and the power of astigmatism is -3-(-2) = -1.0 diopter.

The block diagrams 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. An eye testing device to measure refractive errors or visual acuity, said device comprising:

a screen to display one or more characters, symbols or predefined patterns, the screen being tilted at a predefined angle;

an optical module for demagnifying the displayed one or more characters or symbols and for defining an optical path, said module comprising:

a first mirror positioned in substantially vertical position to reflect the demagnified one or more characters or symbols;

a second mirror to receive the reflected one or more characters, symbols or predefined patterns from the first mirror and to reflect further demagnified one or more characters or symbols to an eye of a subject through a first lens, said first lens being positioned between the second mirror and the eye of the subject.

2. The eye testing device according to claim 1, wherein the predefined angle is in a range between 10^{o} to 45^{o}.

3. The eye testing device according to claim 1 or 2, wherein the first mirror is a plane mirror.

4. The eye testing device according to any one of claims 1 to 3, wherein the second mirror is a convex mirror.

5. The eye testing device according to any one of claims 1 to 4, wherein the second mirror is tilted at a second predefined angle relative to the first mirror.

6. The eye testing device according to claim 5, wherein the second predefined angle is in a range between 8^{o} to 25^{o}, preferably 13^{o}.

7. The eye testing device according to any one of claims 1 to 6, wherein the lens is a positive or convex lens.

8. The eye testing device according to any one of claims 1 to 7, wherein said optical module further comprising a second lens placed between the second mirror and the first lens.

9. The eye testing device according to claim 8, wherein the second lens is a negative or concave lens.

10. The eye testing device according to any one of claims 1 to 9, wherein said device is a self-administered device.

11. The eye testing device according to any one of claims 1 to 10, wherein said screen and optical module are placed within a housing.

12. The eye testing device according to claim 11, wherein said housing is mounted on a positioning arm.

13. The eye testing device according to any one of claims 1 to 12, wherein the device further comprising an opening at a proximal section of the device, said opening is configured to engage with an eyepiece.

14. The eye testing device according to any one of claims 1 to 13, wherein the device further comprising a camera.

15. A method to measure refractive errors or visual acuity using a device, said device comprising:

a screen to display one or more characters, symbols or predefined patterns, the screen being tilted at a predefined angle;

an optical module for demagnifying the displayed one or more characters, symbols or predefined patterns and for defining an optical path, said module comprising:

a first mirror positioned in substantially vertical position to reflect the demagnified one or more characters, symbols or predefined patterns;

a second mirror to receive the reflected one or more characters, symbols or predefined patterns from the first mirror and to reflect further demagnified one or more

characters, symbols or predefined patterns to an eye of a subject through a first lens, said first lens being positioned between the second mirror and the eye of the subject; said method comprising the steps of:

positioning the eye of the subject on an opening at proximal section of said device;

directing the optical path defined by the optical module of said device towards the eye of the subject to display demagnified one or more characters, symbols or predefined patterns, wherein said one or more characters, symbols or predefined patterns are to be read by the subject.

16. The method according to claim 15, further comprising determining the refractive errors or visual acuity by means of identifying whether the subject is able to read the one or more characters, symbols or predefined patterns.

17. The method according to claim 15 or 16, wherein determining the refractive errors comprising adjusting a user interface in the device such that the subject is able to identify the predefined pattern displayed on the screen, and wherein the number of adjusting steps required is indicative of the power of refraction.

18. The method according to any one of claims 15 to 17, wherein said opening is configured to engage with an eyepiece.

19. The method according to claim 18, wherein determining the refractive errors further comprising:

rotating the eyepiece to a first rotation angle;

adjusting the user interface defined by a first number of adjusting steps required, such that the subject is able to identify a first predefined pattern displayed on the screen;

rotating the eyepiece to a second rotation angle, said second rotation angle is different from the first rotation angle;

adjusting the user interface defined by a second number of adjusting steps required, such that the subject is able to identify a second predefined pattern displayed on the screen;

rotating the eyepiece to a third rotation angle, said third rotation angle is different from the first rotation angle and the second rotation angle; and

adjusting the user interface defined by a third number of adjusting steps required, such that the subject is able to identify a third predefined pattern displayed on the screen;

wherein the power of astigmatism is defined by subtracting the most number of adjusting steps required with the least number of adjusting steps required.

20. The method according to claim 19, further comprising:

rotating the eyepiece to a fourth rotation angle, said fourth rotation angle is different from the first rotation angle, the second rotation angle and the third rotation angle;

adjusting the user interface defined by a fourth number of adjusting steps required, such that the subject is able to identify a fourth predefined pattern displayed on the screen; and

wherein the power of astigmatism is defined by subtracting the most number of adjusting steps required with the least number of adjusting steps required.

21. The method according to claim 19 or 20, wherein the least number of adjusting steps required is indicative of the myopic power.

22. The method according to any one of claims 19 to 21, wherein the rotation angle at which the most number of adjusting steps is required is indicative of the angle of astigmatism.

23. The method according to any one of claims 18 to 22, wherein said eyepiece is a circular eyepiece comprising two holes.

24. The method according to claim 23, wherein said two holes are equally spaced apart with respect to the center of the eyepiece.

25. The method according to claim 23 or 24, wherein before the first rotation, said two holes are equally spaced apart with respect to the center of the eyepiece in vertical direction.

26. The method according to any one of claims 17 to 25, wherein each of the adjusting steps required represents about -0.5 diopters defined through calibration.

27. The method according to claim 26, wherein said calibration is undertaken using a camera.