

EYE TRACKING DEVICE

1. FIELD OF THE TECHNOLOGY

5 The field of the technology relates to devices, systems and methods for tracking movement of the eye. In particular, but not exclusively, the field relates to eye tracking devices for obtaining information on eye tracking for use in assessing medical conditions, for example in the ability of the eye to follow a target.

10 2. BACKGROUND TO THE TECHNOLOGY

The human eye is a complex and delicate organ used to perceive the world around us. The eye captures light and forms an image on the retina. This generates electrical signals which are transmitted to the brain and interpreted as visual information. Scientists and medical professionals have come to
15 understand the importance of tracking eye movement in diagnosing and treating various medical conditions. In particular, the movement of the eye has been found to be a useful indicator of brain function, including the presence of certain medical conditions.

One example of a medical condition that the movement of the eye may be used to assess is traumatic
20 brain injury, including mild traumatic brain injury (mTBI) or concussion. Mild traumatic brain injury is a complex neurobehavioral phenomenon caused by deformation of the brain tissue under acceleration of the head. This may also be caused by mechanical forces directly impacting the skull. It can cause a range of symptoms, including headaches, dizziness, fatigue, depression, anxiety, irritability, loss of consciousness and impaired cognitive function, which may last between days and years as
25 microstructural damage to axons and neurometabolic changes result in brain network disruption. The impact of a concussion can affect the brain's ability to control eye movements, leading to symptoms such as double vision, blurred vision, and problems with coordination.

The diagnosis of a concussion may be based on a combination of self-reported symptoms, and physical
30 and neurological examinations. One classic method is a physician asking the patient to look at their finger as they move it around and watch how the patient's eyes track the movement. Such methods can be subjective and prone to error, and may ideally require a clinical environment suitable for careful tests.

There are many situations where a quick, accurate assessment of the likelihood of a concussion may be required away from clinical environments. Such situations include during play of a contact or combat sport, for example football (NFL, soccer, Australian rules), rugby, boxing, martial arts, etc, or at the scene of an injury, for example a road vehicle accident.

More reliable diagnosis methods like brain imaging such as CT and MRI scans require expensive, bulky equipment that is not portable and therefore not suitable for in situ diagnoses as required in the above situations.

Scientists are also increasingly understanding that other types of medical condition may also be assessed by observation of the movement of the eye.

One example of an existing system to help assess concussion is the EyeBOX® by Oculogica. This system requires a dedicated terminal which, although marketed as “portable”, is the size of a computer screen.

Another example is described in US Patent No. 10,849,492, however this device images the eye using the front facing wide angle camera of a smartphone held at arm’s length. As a result the image of the eye is captured with few pixels which makes it difficult to accurately image and assess the eye’s movement.

Other examples include AR/VR headsets. However in such headsets, cameras are positioned to image the eye at a position that is at a significant angle to the eye. This reduces the resolution of the captured images of the eye and makes assessment of eye movement less accurate.

There is a need for more tools that allow the evaluation of medical conditions through eye movement in a way that is more convenient, objective and/or accurate than certain existing diagnostic tools.

3. OBJECT OF THE TECHNOLOGY

It is an object of the technology to provide an improved device, system and/or method for tracking movement of an eye.

Alternatively, it is an object of the technology to provide a frame suitable for use in a device for tracking movement of an eye, for example in its ability to follow a target. Alternatively, it is an object of the technology to at least provide the public with a useful choice.

5 **4. SUMMARY OF THE TECHNOLOGY**

According to certain aspects of the technology, there is provided a device for tracking movement of an eye, for example in its ability to follow a target.

10 In some forms, the device comprises a display screen to show a target for viewing by the eye and a camera for imaging the eye when the eye is viewing the display screen. The device may also comprise a frame configured to position the display screen and the camera relative to the eye during use. The frame may comprise a housing to house the display screen and the camera in a light-controlled environment, the housing comprising an aperture for the eye to be presented to during use of the
15 device.

According to one aspect of the technology, there is provided a device for tracking movement of an eye, the device comprising:

 a reflector;
20 a display screen positioned relative to the reflector such that, in use, the eye views the display screen reflected in the reflector; and
 a camera for imaging the eye when the eye is viewing the display screen.

In certain forms, the camera is positioned to image the eye through the reflector.

25

In some forms, the reflector comprises an opening and the camera is positioned to image the eye through the opening in use.

In alternative forms, the reflector may be semi-transparent and the device is configured so that the
30 camera is able to image the eye through the reflector and the eye is able to view the display screen reflected in the reflector. For example, the reflector may comprise a one-way mirror.

In certain forms, the device is configured such that, when viewing the display screen, the eye substantially fills the field of view of the camera. In certain forms, the device further comprises a lens positioned such that the camera images the eye through the lens. In certain forms the lens may be a macro lens.

5

In certain forms, the device is configured so that, during use, the camera is positioned substantially directly in front of, i.e. directly anterior to, the eye. In other forms, the device may be configured such that the camera is positioned anterior and inferior to the eye during use.

- 10 In certain forms, the reflector has a reflective side configured to reflect light from the display screen towards the eye, and the reflective side is concave in at least one plane.

In certain forms, the device further comprises a frame configured to position the reflector, the display screen and the camera relative to the eye during use. The frame may comprise a housing to house the reflector, the display screen and the camera in a light-controlled environment, the housing comprising an aperture for the eye to be presented to during use of the device. In certain forms, the housing substantially prevents ambient light from entering the light-controlled environment during use, for example light to illuminate the eye may be provided by the display screen. The housing may take an alternative or additional form, for example in accordance with one of the other aspects of the technology described below.

20

In certain forms, the device comprises one or more light sources. In some forms, the one or more light sources may comprise the display screen. Additionally or alternatively, the one or more light sources may comprise one or more light sources separate to the display screen. The one or more light sources may be a source of diffuse light. In some forms, the one or more light sources may be positioned to one or more sides of the eye during use. For example, the device may comprise two light sources positioned to the side of the eye during use, with one of the light sources positioned on a lateral side of the eye and the other light source positioned on a medial side of the eye. In some forms, the one or more light sources may be adjustable in brightness. Additionally or alternatively, the frequency of light produced by the one or more light sources may be adjustable.

25

30

In certain forms, the display screen is comprised as part of a first portable electronic device, for example a first smartphone.

In certain forms, the camera is comprised as part of a second portable electronic device, for example a second smartphone. In some forms, the display screen of the device for tracking movement of an eye may be a first display screen and the second portable electronic device may comprise a second display screen for displaying images captured by the camera. Additionally, or alternatively, the camera may be configured to store and/or transmit images captured by the camera for viewing and/or analysis remote from the device, eye and/or camera.

In some forms, the device may be configured so that the camera of the second portable electronic device is inside the light-controlled environment and the second display screen of the second portable electronic device is outside the light-controlled environment.

In certain forms, the reflector may be a first reflector and the device may further comprise a second reflector. The eye may be a user's first eye and the user may have a second eye. The display screen may be positioned relative to the first and second reflectors such that, in use, the first eye views the display screen reflected in the first reflector and the second eye views the display screen reflected in the second reflector. The camera may be a first camera and the device may further comprise a second camera for imaging the second eye when the second eye is viewing the display screen. The second camera may be positioned to image the second eye through the second reflector.

According to another aspect of the technology there is provided a frame suitable for use in a device for tracking movement of an eye, the frame comprising:

- a reflector retaining structure to position a reflector;
- a display screen retaining structure to position a display screen relative to the reflector when the reflector is positioned in the reflector retaining structure such that, in use, the eye views the display screen reflected in the reflector; and
- a camera retaining structure to position a camera for imaging the eye when the eye is viewing the display screen.

In certain forms, the camera retaining structure is configured to position the camera and the reflector retaining structure is configured to position the reflector such that, in use, the camera images the eye through the reflector. For example, the reflector may comprise an opening and the camera may be positioned to image the eye through the opening in use.

In another example, the reflector may be semi-transparent and the device is configured so that the camera is able to image the eye through the reflector and the eye is able to view the display screen reflected in the reflector. For example, the reflector may comprise a one-way mirror.

5

In certain forms, the frame is configured such that, when viewing the display screen, the eye substantially fills the field of view of the camera. In certain forms, the frame further comprises a lens retaining structure to position a lens such that, in use, the camera images the eye through the lens. In certain forms the lens may be a macro lens.

10

In certain forms, the frame comprises a housing to house the reflector, the display screen and the camera in a light-controlled environment, the housing comprising an aperture for the eye to be presented to during use of the device. In certain forms, the housing substantially prevents ambient light from entering the light-controlled environment other than through the aperture.

15

In certain forms, the display screen retaining structure may comprise a first slot for receiving the display screen. The camera retaining structure may comprise a second slot for receiving the camera.

In certain forms, the housing comprises a first housing part and a second housing part, wherein the first housing part and the second housing part are configured to be assembled together to form the housing. In some forms, the first housing part comprises the display screen retaining structure. The first housing part may further comprise the camera retaining structure. In some forms, the second housing part may comprise the aperture.

20

In certain forms, the display screen is comprised as part of a first portable electronic device, for example a first smartphone. In such forms, the first slot may be configured to receive the first smartphone.

25

In certain forms, the camera is comprised as part of a second portable electronic device, for example a second smartphone. In such forms, the second slot may be configured to receive the second smartphone. In some forms, the display screen of the device for tracking movement of an eye may be a first display screen and the second portable electronic device may comprise a second display screen for displaying images captured by the camera. In some forms, the housing may be configured so that the camera retaining structure positions the camera of the second portable electronic device inside the

30

light-controlled environment and the second display screen of the second portable electronic device is outside the light-controlled environment.

In certain forms, the reflector retaining structure may be a first reflector retaining structure and the reflector may be a first reflector. The device may further comprise a second reflector retaining structure to position a second reflector. The eye may be a user's first eye and the user may have a second eye. The display screen retaining structure may position the display screen relative to the first and second reflectors such that, in use, the first eye views the display screen reflected in the first reflector and the second eye views the display screen reflected in the second reflector. The camera retaining structure may be a first camera retaining structure and the device may further comprise a second camera retaining structure to position a second camera for imaging the second eye when the second eye is viewing the display screen. The second camera retaining structure may be configured to position the second camera to image the second eye through the second reflector.

Further aspects of the technology, which should be considered in all its novel aspects, will become apparent to those skilled in the art upon reading of the following description which provides at least one example of a practical application of the technology.

5. BRIEF DESCRIPTION OF THE DRAWINGS

One or more embodiments of the technology will be described below by way of example only, and without intending to be limiting, with reference to the following drawings, in which:

Figure 1A is a front view illustration of a human eye;

Figure 1B is a cross-section of the eye 101 of Figure 1A in a sagittal plane;

Figure 2 is a schematic illustration of an eye tracking device according to one exemplary form of the technology;

Figure 3 is a schematic illustration of an eye tracking device according to a further exemplary form of the technology;

Figures 4A-C are schematic illustrations of an eye tracking device according to further exemplary forms of the technology;

Figure 5 is a schematic illustration of part of an eye tracking device according to a further exemplary form of the technology;

- Figures 6A-D are illustrations of a frame of an eye tracking device according to one form of the technology;
- Figures 7A-B are illustrations of movements of a target on a display screen according to certain forms of the technology;
- 5 Figures 8A-B are schematic illustrations of the positioning of light sources according to exemplary forms of the technology;
- Figures 9A-D are schematic illustrations of eye tracking devices according to further exemplary forms of the technology;
- Figures 10A-B are schematic illustrations of an eye tracking device according to a further exemplary form of the technology; and
- 10 Figure 11 is a schematic illustration of an eye tracking device according to a further exemplary form of the technology.

15 6. DETAILED DESCRIPTION OF EXEMPLARY FORMS OF THE TECHNOLOGY

6.1. Eye

Forms of the technology are directed to devices, systems and methods for tracking movement of an eye, for example in the ability of the eye to follow a target. Some relevant aspects of the anatomy and movement of the eye will now be described. Forms of the technology are primarily concerned with tracking movement of a human eye although.

20

In this specification, anatomical terms of location relative to the body may be used, for example "superior", "inferior", "anterior", "posterior", etc. These are used as convenient labels to provide clarity to the position of components in exemplary forms of the technology relative to the body of a patient or subject of the eye tracking assessment during use of the technology and to accommodate the prospect that the patient may not necessarily be in a vertical (e.g. standing) orientation when the technology is used. It should be understood that the use of these terms to describe the relative position of certain components does not require the device and its components to be so situated with respect to a body at all times. A device may be removed from proximity with the body and/or may be oriented differently while still existing as the same device and embodying certain forms of the technology.

25

30

6.1.1. *Anatomy of the Eye*

Figure 1A is a front view illustration of a human eye 101, including eyeball 104 and pupil 106. Movement of the eye 101 may be characterised by movement of the eyeball 104 and/or the pupil 106 in two mutually perpendicular axes, for example an axis in the lateral direction relative to the body (i.e. the horizontal direction when the body is standing upright), illustrated as x-axis 107 in Figure 1A, and an axis in the superior-inferior direction relative to the body (i.e. the vertical direction when the body is standing upright), illustrated as y-axis 108 in Figure 1A. These axes are also illustrated on Figure 1B, which is a cross-section of the eye 101 of Figure 1A in a sagittal plane (vertical when the body is standing upright).

6.1.2. *Movement of the Eye*

Bodies have muscles that control movement of the eyeball 104. In the human eye 101, these are the extraocular muscles and the intrinsic eye muscles. The main function of the extraocular muscles, of which there are seven per eye, is to control eye movement and eye alignment. There are three intrinsic eye muscles per eye and they control movement of the lens and pupil dilation, which enable the eye to focus on near objects and control how much light enters the eye.

Multiple different types of eye movement have been characterised, including:

- Saccades – are rapid, ballistic movements of the eyes that abruptly change the point of fixation. They range in amplitude from, for example, the small movements made while reading to the much larger movements made while gazing around a room. Saccades can be elicited voluntarily, but occur reflexively whenever the eyes are open, even when fixated on a target;
- Microsaccades – are a kind of fixational eye movement. They are small, jerk-like, involuntary microscopic eye movements, similar to miniature versions of voluntary saccades. They typically occur during prolonged visual fixation to prevent fading;
- Square-wave jerk – a form of fixational eye movement which move away and back from a fixation at equal magnitudes, occurring within approximately 200-500 ms;
- Prosaccades – a saccade towards a target, generally reflexively generated;
- Antisaccade – a saccade away from a target, generally volitionally generated;

- Drift – the brain mechanisms behind ocular drifts are not fully known, but these are slower, more gradual movements that take place between microsaccades, during fixation;
- Tremor – small, high-frequency perturbations that take place between microsaccades;
- Fixational eye movements: for example microsaccades, square-wave jerks, tremor, and drift;
- 5 • Fixation: a fixation is composed of slower and minute movements (fixational eye movements) that help the eye align with the target and avoid perceptual fading. The duration may vary between, for example 50-600 ms; and
- 10 • Smooth pursuits: these are movements that are much slower tracking movements of the eyes designed to keep a moving stimulus on the fovea. Such movements are under voluntary control in the sense that the observer can choose whether or not to track a moving stimulus and occur between saccades.

Forms of the technology may be used to track any one or more of these types of eye movement.

- 15 Eye movement dysfunction occurs when there is some abnormality or impairment of normal eye movement, for example saccades and smooth pursuits may be inaccurate with reference to a target, or may be interrupted in motion or irregular in timing. Saccade dysmetria is a motor error resulting in over or under shoot of the eye to the target accompanied by corrective saccades. Certain measures may be used to quantify eye movement dysfunction, for example saccade gain is the ratio of the eye movement
- 20 to target location, and stimulus delay is the delay in reaction before the onset of the motor command when stimulus in the form of a target is presented in the visual plane.

6.1.3. *Eye Tracking*

- 25 Forms of the technology relate to devices, systems and method for “tracking” movement of the eye 101. Unless the context clearly indicates otherwise, the term “tracking” is intended to mean the act of identifying the way in which the eye 101 moves over a period of time. By identifying movement of the eye 101, the movements may be able to be characterised and analysed. In certain forms, movement of the eye 101 is tracked by observing movement of the pupil 106. The pupil 106 is the aperture through
- 30 which light enters the internal parts of the eye 101 and its position is therefore indicative of the direction of the eye’s vision. The eye is tracked in its ability to follow a target, for example which moves on a display screen presented to the eye. Any errors in tracking the target may be characterised and analysed.

6.2. Eye Tracking Device / System

There will now be described exemplary forms of devices and/or systems 200 for tracking movement of an eye according to certain forms of the technology. Such devices / systems may otherwise be referred to as eye tracking devices / systems 200.

6.2.1. Components of Eye Tracking Device / System

Some components common to several of the exemplary forms of the technology will now be described. It will be understood that, where these components are later described in the context of particular forms of eye tracking devices / systems, the description of the components in this section applies to any of the forms of the technology unless explicitly stated otherwise.

6.2.1.1. Display Screen

In certain forms of the technology, the eye tracking device 200 comprises one or more display screens, for example first display screen 210 and second display screen 211. The display screens 210, 211 may comprise any device configured to present information visually to a viewer. The information may be in the form of images, for example. The display screens 210, 211 may be controllable to alter the information displayed to the viewer. For example, a moving target may be displayed to the viewer and may follow different testing protocols such as described in more detail later. The range of ocular motion may be important in detecting some medical conditions, so in certain forms the display is positioned to occupy over 100° of the field of view and, in some forms, the eye tracking device may be configured so that the display occupies approximately 120° of the field of view. This means the target may be moved on the display so the viewer must move their eye larger distances to follow the target's movement (e.g. up, down, left and right).

In certain exemplary forms, one or more of the display screens 210, 211 are an electronic display, for example an LCD, LED, OLED screen. The information displayed on the display screens 210, 211 may be controllable by a controller or microprocessor, which may be comprised as part of the display screen 210, 211, or may be configured to control the display screen 210, 211 through a physical or wireless

connection. In some forms, the display screen 210, 211 is comprised as part of an electronic device, for example a portable electronic device 250 such as a smartphone, tablet, laptop computer or the like.

5 In some forms, each of the display screens 210, 211 may be self-illuminating, for example the display screen 210, 211 may comprise light-emitting elements such as LEDs. In other forms, either or both of the display screens 210, 211 may be non-self-illuminating, for example the display screen may display information using electronic ink (e-ink). In such forms, a separate light source may be used to illuminate the display screen.

10 6.2.1.2. Light Source

In certain forms, the eye tracking device 200 may comprise a light source. The light source 350 may be a source of diffuse light. The light source may be positioned somewhere suitable to illuminate eye 101 during use of the device 200. In certain forms, the light source may comprise the first display screen 210 and, in some forms, the first display screen 210 may be the sole source of illumination. This may enable the illumination of the eye 101 to be well controlled, diffuse, covering a large angle of over 100° (for example approximately 120°, which may help avoid specular reflections) and consequently illuminated in a manner which is suitable for imaging the eye 101.

20 For example, images with reasonably uniform intensity across the display screen 210 may be displayed in order to provide diffuse lighting and produce a uniform lighting distribution of the eye 101. In addition, the display screen 210 may be controlled, for example the image displayed on the display screen 210 may be selected, so that the amount of light produced by the display screen 210 is sufficient to adequately illuminate the eye 101 in order to capture images suitable for tracking its movement. For example, a well illuminated eye may assist in using a camera 220 operating at a high frame rate in order to be able to image very rapid movements of the eye 101, for example saccades, and to image the eye at a sufficiently high resolution.

30 In other forms of the technology, the eye tracking device 200 may comprise one or more light sources 350 separate to the display screen 210. In certain forms, for example as shown in Figures 8A and 8B, the light source 350 may be positioned to one or more sides of the eye 101 during use. In some forms (again as shown in Figures 8A and 8B), there may be two light sources 350 positioned to the sides of the eye 101 during use, with one of the light sources 350 positioned on a lateral side of the eye and the other

light source 350 positioned on a medial side of the eye. Positioning the light sources 350 in this way may help to illuminate the eye without creating shadows from the eyelids and/or eyelashes. In addition, the light sources 350 do not project light directly into the pupil 106. In some forms, the light sources 350 may comprise hoods (e.g. opaque barriers) that prevent light from the light sources 350 shining directly into the camera 220. This may help generate high contrast images of the pupil 106 compared to the sclera and iris even at very high speeds of camera, e.g. over 200 frames per second. It may also reduce the user's pupillary constriction and reduce discomfort for photosensitive users.

As shown in the example of Figure 8B, to illuminate the eye 101 with diffuse light, the device 200 may comprise one or more diffusers 352. Each diffuser may be positioned in front of one or more of the light sources 350 in order to diffuse the light emitted by the light sources.

In certain forms, the light sources, which may be the display screen 210 and/or separate light sources 350, may be adjustable in brightness. Being able to reduce the brightness of the light sources may be useful to ease the comfort of patients during use of eye tracking device 200, particularly those who are photosensitive. In addition, changing the brightness of the light may be useful to generate different types of reflection from pigments in the iris, which may be desired for certain types of analysis of the eye 101. For example, in forms in which the display screen 210 is a smartphone, the brightness may be adjusted in a conventional manner. In other forms, the eye tracking device may comprise one or more light sources 350 in the form of LEDs. The LEDs may be configured to be adjusted in brightness.

Additionally or alternatively, in certain forms, the frequency of light produced by the light sources, which may be the display screen 210 and/or separate light sources 350, may be adjustable. For example, the light source may be configured to selectively generate light of one or more parts of the electromagnetic spectrum, for example red light, blue light and near-infrared light. The light source may also be selected to generate white light. It will be appreciated that this list of light spectra able to be generated by the light sources in certain forms is non-exhaustive. Changing the frequency of the light may be useful to generate different types of reflection from pigments in the iris, which may be desired for certain types of analysis of the eye 101.

30

6.2.1.3. Camera

In certain forms of the technology, the eye tracking device 200 comprises a camera 220. The camera 220 may comprise any optical device configured to capture and record visual images. The captured images may be displayed on a display screen, which in some forms may be the second display screen 211 comprised as part of the eye tracking device 200 while in other forms the camera may be configured to
5 transmit the images to another device, which may itself comprise a display screen for displaying the images or a memory for storing the images for display elsewhere. The images may be transmitted through a wired or wireless connection, for example to a display screen located remote from the eye tracking device 200. The images may be displayed on the display screen in real-time, near-real-time, or at a later time compared to when the images are captured by the camera. In some forms, the camera
10 220 comprises a memory configured to store the visual images. It should be appreciated that, in certain forms, the camera 220 is a digital camera and reference to images may mean the data recorded by the camera as being representative of the image.

In certain exemplary forms, the camera 220 is comprised as part of an electronic device, for example a
15 portable electronic device 250 such as a smartphone, tablet, laptop computer or the like. In such forms, the camera 220 comprises display screen 211, which may be configured to display the images captured by the camera 220.

6.2.1.4. Reflector

20

In certain forms of the technology, the eye tracking device 200 comprises a reflector 230. The reflector 230 is a structure able to reflect light incident on the reflector.

The reflector 230 may comprise a reflective side 232 which in certain forms may comprise a mirror. As
25 will be explained, in some forms of the technology, the reflector 230 may at least in part comprise a one-way mirror (which may also be referred to as a half-silvered or semi-transparent mirror) such that the reflector 230 reflects light incident on the reflective side 232 but transmits light incident on another side. In other forms, the reflector 230 may comprise a prism configured to reflect incident light.

30 As will be explained in more detail further below, in some forms the reflector 230 may be non-planar, or curved, for example concave in at least one plane.

6.2.2. First Exemplary Form of Eye Tracking Device

Figure 2 is a schematic illustration of an eye tracking device 200 according to one exemplary form of the technology. The eye tracking device 200 comprises a display screen 210 and a camera 220. In the illustrated form, both display screen 210 and camera 220 are comprised as part of a portable electronic device 250, for example a smartphone or tablet, although in other forms the display screen 210 and camera 220 may be provided as separate components. The device 200 is positioned so that an eye 101 may view the display screen 210 and the camera 220 may image the eye 101 when the eye is viewing the display screen 210.

In at least one example the relative positioning of the display screen, camera and eye is such that the camera tracks the eye movement as it follows a target at substantially the same angle as the direction of the eye's gaze, thus giving accurate real-time data useful to detect medical conditions linked to delayed or erratic eye movement. Unlike traditional fixation tracking which is used for driving user interfaces, for successfully extracting the important metrics of saccadic eye movement, the camera 220 may in certain forms operate at over 200Hz with enough angular accuracy to track pupil movement to approximately 50 microns or better. Also, locating the camera centrally relative to the eye (i.e. substantially directly anterior to the eye) means that the pupil is visible as it rotates with the eye when following a target on the display screen 210 through a large range of ocular motion. In comparison, a camera that is offset from this position will suffer from the pupil being occluded in some orientations due to the spherical nature of the eye.

This configuration is simple and may require only a single device, for example a smartphone or tablet, to implement the eye tracking system. However, imaging of the eye 101 may be low resolution because the device needs to be held sufficiently far from the eye for the patient to be able to focus on the display screen 210. A typical mature human eye may find it difficult to focus on anything that is closer than approximately 200 mm from the eye. At this range, the camera on a typical smartphone or tablet would image the eye 101 with only a subset of the available imaging field of view, which may not provide high enough resolution for detailed eye tracking, particularly of some of the smaller movements described above. On the other hand, positioning the display screen 210 further from the eye 101 constrains the range of the motion the eye exhibits in following a target on the display screen because the display screen occupies a smaller proportion of the field of view of the eye the further it is positioned from the eye. Symptoms of some medical conditions may require a full ocular range of eye

movement to be exhibited. In addition, in this form of the technology, ambient light illuminates the eye 101 and the variable intensity and quality of ambient light may affect imaging quality.

6.2.3. *Schematic Layout of Further Exemplary Forms of Eye Tracking Device*

5

To address the aforementioned drawbacks with the form of the technology shown in Figure 2, other forms of the technology make use of a reflector 230. This advantageously enables the optical distance from the eye 101 to the display screen 210 to be increased, while maintaining the camera 230 at a position to image the eye 101 at relatively close proximity and consequently with high resolution, as will now be explained.

10

Figures 3, 4A to 4C, 5, 9A to 9D, 10A and 10B are schematic illustrations of eye tracking devices 200 according to such further exemplary forms of the technology. As shown in these figures, the eye tracking device 200 comprises a display screen 210 and a reflector 230. The display screen 210 is positioned relative to the reflector 230 such that, in use, the eye 101 views the display screen 210 reflected in the reflector 230, as shown by the rays indicated in Figures 4C, 9A to 9D and 10A. In the form shown in Figures 4A to 4C, the display screen 210 may be comprised as part of a portable electronic device 250, which is positioned proximate a patient's body with the display screen 210 facing away from the patient. The reflector 230 is positioned anterior to the eye 101 and further from the patient than the display screen 210. The display screen 210 and reflector 230 are positioned and oriented to enable the eye 101 to view a reflection of the display screen 210 in the reflector 230, i.e. so that light emitted by the display screen 210 reflects off a reflective side 232 of the reflector 230 and is incident on the eye 101. In the illustrated form, the reflector 230 is oriented with a reflective side 232 facing generally towards the display screen 210 and eye 101, i.e. the display screen 210 and eye 101 are positioned on the same side of the reflector 230.

15

20

25

As shown schematically in Figures 3 and 4A to 4C, during use, the display screen 210 may be positioned superior to the eye 101. For example, the display screen 210 may be positioned anterior to (e.g. directly in front of) the patient's forehead. The display screen 210 may be tilted accordingly to enable the eye 101 to view the display screen 210 on reflection from the reflector 230, for example as shown in Figures 4A to 4C, the superior end of the display screen 210 may be positioned more anteriorly (i.e. further from the patient's body) than the inferior end of the display screen 210. In other forms, the display screen 210 may be positioned in a different position and/or in a different orientation. For example, in some

30

forms, the display screen 210 may be positioned inferior to the eye 101, for example directly anterior to the patient's cheek. In other forms, such as shown in Figures 9A to 9D and 10A, the display screen 210 may be positioned at a similar distance in front of the patient's body as the reflector 230 and may be located directly superior to, or inferior to, the reflector 230. It will be appreciated that, irrespective of
5 the position of the display screen 210, it is oriented appropriately so that the eye 101 may view what is displayed on the screen as reflected in the reflector 230. For example, in the case of the display screen 210 being located directly superior to the reflector 230 such as shown in Figures 9A to 9D and 10A, the display screen 210 is oriented with the plane of the screen generally parallel to the patient's transverse (or horizontal) plane and with the display screen 210 facing in the inferior direction towards the
10 reflector 230 which is positioned directly inferior to it.

In certain forms, for example as shown in Figures 3 and 4A to 4C, the reflective side 232 of the reflector 230 may be concave. The concave shape of the reflective side 232 may assist in reflecting light from the display screen 210 into the eye 101. This shape may also assist in keeping the overall size of the device
15 200 relatively compact, e.g. allowing the viewer to focus on the display 210 while still enabling all of the display screen 210 to be in focus with a wide field of view, for example of over 100°, for example 120°. That is, the concave reflector 230 makes the display screen 210 appear further away to the eye 101, and easier to focus on compared to its actual distance. For example, in certain examples, the reflective side 232 of the reflector 230 may be positioned approximately 40-80 mm, for example 60 mm, from the eye
20 101 during use. The display screen 210 may be positioned at approximately a similar distance from the reflector 230 during use. The optical properties of the reflector 230 may resolve the image in a way it is in focus for a wide field of view of the eye 101, for example approximately 100° degrees or more, which may enable testing the viewer's ocular range.

25 In some forms of the technology, the reflector 230 may be concave in multiple planes while in other forms of the technology, the reflector 230 may be concave in a single plane. For example, the schematic illustrations of the devices 200 in Figures 4A to 4C, 5 and 9A to 9D show a cross-section of the reflector 230 through a first plane which is oriented parallel to a sagittal (or longitudinal) plane of the body when the device 200 is in use. The reflector 230 has a concave cross-section in this first plane. A second plane
30 may be oriented perpendicularly to the first plane, for example the second plane may be horizontally oriented, or parallel to a transverse (or horizontal) plane of the body. In this second plane, the reflector 230 may also be concave, or the reflector 230 may have a straight cross-section. In the example of Figure 3, the reflector 230 is also concave in this second plane.

In certain forms in which the reflector 230 is concave, the surface of the reflector may, in part, form part of the surface of an asphere to reflect the flat display suitable for a spherical human eye. Another part of the surface of the reflector, or in other forms all of the surface of the reflector, may form part of the surface of a paraboloid, for example to reflect the part of the display which is off-axis to the human eye. In one example, a central region of the reflective side 232 of the reflector 230 has the shape of a radially distributed asphere. For example, the aspherical surface may be an axially symmetric quadric surface. This may help the eye 101 to focus on the flat plane of the display screen 210, despite the centre of the display screen 210 being closer to the eye 101 than the edges of the display screen 210. The asphere may also help reduce or eliminate spherical aberration and other optical aberrations such as astigmatism, when compared to a more simple shape for the reflector. In addition, top and bottom (i.e. inferior and superior) regions of the reflective side 232 may have a curvature increasing progressively towards the edge of the reflector 230, e.g. the surface of a paraboloid. The light from the display screen 210 reflects off the reflector 230 and the eye 101 is therefore a different distance away from the top of the screen compared to the bottom of the screen. The paraboloid shape translates the different light paths between the eye 101 and different parts of the display screen 210 into a common focus.

Forms of eye tracking device 200 further comprise a camera 220 for imaging the eye 101. The camera 220 is positioned suitably so that the camera 220 is able to image the eye 101 when the eye is viewing the display screen 210. In certain forms of eye tracking device 200, for example as shown in Figures 4A and 4C, the camera 220 is positioned to image the eye 101 through the reflector 230. In this context, "through the reflector" means that the camera 220 is positioned on the other side of the reflector 230 to the eye 101, i.e. more anteriorly than the reflector 230, so that light from the eye 101 passes from one side of the reflector 230 to the other side of the reflector 230 before being captured by camera 220 (as opposed to referring to light reflected by the reflector).

The camera 220 may view the eye 101 through the reflector 230 in different ways in different forms of the technology. For example, in the forms shown in Figures 4A to 4C, 9A and 9B, the reflector 230 comprises an opening 234, which may take the form of a small hole through the reflector 230. The opening 234 may be large enough for the camera 220 to image the eye 101 through the opening 234 without the reflector 230 obstructing its field of view, but may be no larger than necessary to achieve this. The smaller the size of the opening 234, the less the opening obstructs the eye's view of the display screen 210 in the reflector 230.

In another example, such as in the form shown in Figure 5, the reflector 230 may be semi-transparent and the device 200 may be configured so that the camera 220, positioned on the opposite side of the reflector 230 to the eye 101, is able to image the eye 101 through the reflector 230 (i.e. with light from the eye 101 passing through the reflector 230) and the eye 101 is able to view the display screen 210 reflected in the reflector 230 (i.e. with light from the display screen 210 being reflected by the reflector 230). It should be understood that “transparent” in this context is intended to refer to the ability for light to pass through the material forming the reflector 230, as contrasted to the reflector 230 having an opening through which light may pass, as in the form of Figure 4A. In some forms, all of the reflector 230 may be semi-transparent, while in other forms, one part of the reflector 230 may be semi-transparent, i.e. the region of the reflector 230 through which the camera 220 views the eye 101. It should be understood that the device may be configured so that the lighting conditions on either side of the reflector 230 may enable the reflector to function in this semi-transparent way, for example with the lighting on the posterior side of the reflector 230 (i.e. the space between the reflector 230 and the eye 101) being relatively bright compared to the lighting on the anterior side of the reflector 230 (i.e. the space between the reflector 230 and the camera 220). Suitable lighting conditions may be established by provision of a housing 262 to house the components of the device in a light-controlled environment, as will be explained later. In certain forms, the reflector 230 may comprise a one-way mirror, which may alternatively be referred to as a half-silvered mirror. In some forms, the mirror may be front-silvered from the perspective of the display screen 210 (i.e. the reflective side 232 may be silvered), and the rear surface (i.e. the surface of the reflector 230 opposite the reflective side 232) may be coated with an antireflective tint. This may help to reduce chromatic aberration and to reduce ghosting from the image on the display screen 210 that the light refracts from air into the mirror material and then back to air.

For the purposes of analysing movement of the eye, it is helpful for the camera 220 to capture images of the eye 101 that have the highest resolution and highest frame rate possible within the limits of the physical and optical configuration of the device 200. To strive to achieve this, the device 200 may be configured such that, when viewing the display screen 210, the eye 101 substantially fills the field of view of the camera 220, for example as shown by the indicative light rays in Figures 4B, 5 and 9A to 9D.

In certain forms, for example as shown in Figures 4A to 4C, 5, 9A and 9B, the device 200 further comprises a lens 225 positioned so that the camera 220 images eye 101 through the lens 225. For example, the lens 225 may be positioned directly in front of the camera 220. In the examples of Figures 4A to 4C, 9A and 9B, the lens 225 is positioned in the opening 234, although it may alternatively be

positioned anterior of the reflector 230, i.e. between the reflector 230 and the camera 220. In the example of Figure 5, the lens is positioned anterior of the reflector 230, i.e. between the reflector 230 and the camera 220. In some forms, the lens 225 may be provided as part of the camera 220. In some forms, the lens 225 may be a macro lens. This may assist the camera to have the necessary field of view for the eye 101 to fill the field of view of the camera 220. For example, for some existing smartphone cameras, an additional corrective optical element (e.g. in the form of a macro lens) may need to be added to allow for a macro-style close focusing so that the viewer's eye is in focus and fills the camera view. In one example, a smartphone camera may have a focal range of approximately 20 cm to approximately infinity and a macro lens may be configured to adjust this focal range to approximately 2 cm to approximately 20 cm. Consequently, the camera 220 with such a lens is able to focus on the user's eye, which may be approximately 40 – 80 mm from the camera. In the case of a dedicated camera sensor then a suitable lens may be selected to allow for the focal range of the position of the viewer's eye relative to the camera, e.g. 40 – 80 mm from the eye in some examples.

In the example of using one typical model of smartphone as the camera 220, the camera 220 may have a sensor of approximately 1,920 pixels wide. If the device 200 is configured so that the eye 101 substantially fills the field of view then, based on a typical eye width of 24.2 mm, each pixel images a part of the eye of 12.6 microns at the centre of the field of view. Greater accuracy may be achieved through image processing methods, for example subpixel tracking. In comparison, a typical microsaccade may be as small as 15 minutes of arc or 0.25° . For an eyeball of width 24.2 mm, this amounts to approximately 53 microns. Consequently, a pixel resolution of less than this may be necessary to successfully track some small eye movements such as microsaccades.

In the examples of Figures 3, 4A to 4C and 5, the eye tracking device 200 is configured so that, during use, the camera 220 is positioned substantially directly in front of, i.e. directly anterior to, the eye 101. This may assist with obtaining a clear image of the eye and having the eye fill the field of view of the camera 220. Another example is illustrated in Figure 9A. In this example, the eye tracking device is configured so that the camera 220 is positioned anterior and inferior to the eye 101 during use. Consequently, the camera 220 is oriented with its line of sight angled slightly superiorly. In this form, the entire eye tracking device 200 may be positioned at a relatively inferior position compared to the eye tracking device 200 of Figures 3, 4A to C and 5. That is, the eye tracking device 200 may be rotated inferiorly around an axis aligned perpendicularly to the body's sagittal plane in comparison with the devices of Figures 3, 4A to D and 5. The display screen 210 may be positioned lower than in those other

forms, for example in the form of Figure 9A, the display screen 210 may be positioned approximately directly anterior to, a superior portion of the eye 101, e.g. a superior part of the orbit. In this arrangement, the eye tracking device 200 may be able to capture a greater range of movement of the eye 101 in the inferior direction compared to the superior direction. For example, the eye tracking
5 device 200 may be configured to capture eye movement of up to approximately 30° in the superior direction and up to approximately 50° in the inferior direction. This may be desirable since the range of movement of a human eye is generally not symmetrical. Positioning the camera 220 inferior to the eye 101 in such a form may be desirable in order to avoid the patient's eyelids obscuring the camera's view.

10 In the form of the technology shown in Figure 9B, the display screen 210 is positioned substantially horizontal with respect to the eye 101. That is, with respect to the body of the subject of the eye tracking, when the eye tracking device 200 is in use, the display screen 210 may lie substantially parallel to the horizontal plane (which may also be referred to as the transverse plane) of the body. In this form, the camera 220 may be positioned substantially directly in front of, i.e. directly anterior to, the eye 101.
15 This may enable camera 220 to be positioned such that its optical axis is substantially parallel to the plane of the display screen 210. Consequently, the camera 220 and the display screen 210 may be mounted substantially perpendicular to each other. This arrangement may facilitate positioning the display screen 210 and the camera 220 in a frame 260, such as described below, since it may simplify the manufacture of a frame 260 that holds two components substantially perpendicular to each other.

20

In a form of the technology such as is shown in Figure 9B where the display screen 210 is positioned substantially horizontal with respect to the eye 101, the reflector 230 may be suitably configured to reflect light from the display screen 210 to the eye in a manner that enables the eye 101 to see the display screen 210 as a substantially undistorted planar image. It will be appreciated that, in this
25 orientation, the distances between different part of the display screen 210 and the reflector 230 may vary, for example an anterior portion of the display screen 210 distal from the eye 101 may be closer to the reflector 230 than a posterior portion of the display screen 210 proximal to the eye 101. In certain forms, a reflector 230 in the form of an asphere modified with a linear parabola may achieve this outcome. The schematic drawing in Figure 9D illustrates some different shapes of reflector 230 in such a
30 configuration. Reflector 230a has an aspherical surface and reflector 230b has a linear vertical parabolic surface, i.e. the parabolic shape may be present in the vertical cross-section such as shown in Figure 9D (i.e. a cross-section parallel to the mid-sagittal plane of the body of the user) but may or may not be present in a horizontal cross-section (i.e. a cross-section parallel to the transverse plane of the body of

the user). Reflector 230c has a surface that is a combination of these two, i.e. a combination aspherical / linear vertical paraboloid shape. When a suitable such shape is selected, the display screen 210 may be able to be seen as a planar image by the eye 101, such as depicted by virtual image 212 in Figure 9D. By way of contrast, the schematic drawing in Figure 9C illustrates a similar arrangement but with a reflector 230a having an aspherical surface only. In this arrangement, to obtain the same virtual image 212, the display screen 210 must be positioned between the eye 101 and the reflector 230a with the eye 101 viewing through an aperture in the reflector 230a. An advantage of the arrangements shown in, for example, Figures 9A, 9B and 9D is that the eye 101 does not need to view through the display screen 210 and therefore conventional devices, for example personal electronic communication devices (e.g. smartphones) can be used to provide the display screen 210.

In addition, achieving a high resolution image and a high frame rate may be assisted by ensuring the eye 101 is sufficiently well illuminated by a dedicated light source, ambient light or a combination. The higher the camera speed, the shorter the exposure time so the more light is required. Also, higher resolution sensors have smaller photo sites for the same size sensor compared to lower resolution sensors, so the more light that is needed to produce a good image. In certain forms, the device 200 comprises a light source to illuminate the eye 101 during use of the device.

6.2.4. *Frame / Housing*

The eye tracking device 200 is illustrated schematically in Figures 3, 4A to 4C, 5, 9A to 9D, 10A and 10B. In certain forms of the technology, the eye tracking device 200 additionally comprises a frame 260, not shown in these Figures, configured to position the other components of the eye tracking device 200 in relation to each other.

In general terms, the frame 260 comprises a plurality of structures that each hold in place one of the other components of the eye tracking device 200 in the desired relative position. The plurality of structures are assembled together as the frame 260. The frame 260 may comprise a reflector retaining structure 264 to position the reflector 230 as described above, a display screen retaining structure 266 to position the display screen 210 relative to the reflector 230 when the reflector is positioned in the reflector retaining structure 264 as described above, and a camera retaining structure 268 to position the camera 220 as described above.

One example of a frame 260 according to a form of the technology is illustrated in Figures 6A to 6D. In this and certain other forms, the frame 260 comprises a housing 262. The housing 262 may encase one or more of the other components of the eye tracking device 200. For example, in the example of Figures 6A to 6D, the housing 262 may encase the reflector 230, the display screen 210 and the camera 220. The housing 262 defines an internal chamber within which these components are housed. The housing 262 may also comprise an aperture 270 for the eye 101 to be presented to during use of the eye tracking device 200. The aperture 270 is positioned in a part of the housing 262 suitably so that, when the eye 101 peers through the aperture 270 into the internal chamber of the housing 262, it is able to view the display screen 210 reflected in the reflector 230, for example the aperture 270 may be positioned in a wall of the housing facing the eye 101 when the device 200 is in use, alternatively referred to as a posterior wall 282 in the description below. The aperture 270 may be sized appropriately for the eye 101 to see through the aperture 270 but not be so large as to allow excessive ambient light into the internal chamber around the eye 101. In some forms, the aperture 270 is circular but in other forms the aperture 270 may be another suitable shape.

The housing 262 may be configured so that the internal chamber is a light-controlled environment, i.e. the amount of light inside the chamber is limited and controlled. In some forms, the housing may be configured to substantially prevent ambient light from entering the light-controlled environment in the internal chamber. As explained above, in some forms, the housing may comprise an aperture 270 and the aperture 270 may be the only way in which ambient light may enter the internal chamber, and ambient light may be limited from entering through the aperture 270 when the device 200 is in use and an eye 101 is positioned close to the aperture 270, at least partially blocking it. In some forms, for example as illustrated in Figures 6A to 6D, one or more of the first display screen 210, second display screen 211 and camera 220 may form, or contribute to forming, a wall of the housing 262 when the eye tracking device 200 is assembled, and any one or more of these components may need to be in place for the ambient light to substantially be prevented from entering the internal chamber of the housing 262. The light-controlled environment may assist in the operation of the eye tracking device 200. For example, by substantially preventing ambient light entering the internal chamber, ambient light is also substantially prevented from entering the camera 220 so the only illumination in the camera's field of view is what is illuminated inside the housing 262.

As explained earlier, the device 200 may comprise a light source. The light source may be housed within housing 262 and positioned somewhere suitable to illuminate eye 101 during use of the device 200. In

certain forms, the light source inside the housing 262 comprises the first display screen 210 and, in some forms, the first display screen 210 may be the sole source of illumination. The sole source of illumination inside the housing 262 being the display screen 210 is conducive to facilitating the reflector 230, when it is semi-transparent and part of an eye tracking device of the form shown in Figure 5, to allow the display screen 210 to display images to the eye 101 while also allowing the camera 220 to image the eye 101 through the reflector 230. In other forms, the one or more light sources 350 may be a source of light other than the first display screen 210. In such forms, the light sources may be positioned proximate the eye 101 and closer to the eye 101 than reflector 230 to facilitate the one-way nature of reflector 230.

10 In the form of the technology shown in Figures 6A to 6D, the housing 262 comprises an anterior wall 280, a posterior wall 282, a first side wall 284, a second side wall 286, a superior wall 288 and an inferior wall 290. As explained earlier, it should be understood that the labels “anterior”, “posterior”, etc, refer to the relative position of the walls when the device 200 is being used to track movement of eye 101 but the device 200 may be removed from the body and/or oriented differently while remaining as the same device. The walls 280, 282, 284, 286, 288 and 290 may be formed together so as to form a light-controlled environment within the housing 262 as explained above.

As shown in Figures 6A and 6C, the housing 262 may comprise the camera retaining structure 268 so that the camera 220 is held adjacent to, or so as to form part of, anterior wall 280. For example, the camera retaining structure 268 may comprise one or more camera slots 269 into which the camera 220 may be slid into in order to position the camera 220 appropriately in the housing 262. In the form shown, the camera retaining structure 268 comprises a camera slot 269 along opposing lateral sides of the anterior wall 280 to retain each end of the camera 220 when the camera is slid into the camera slots 269. In other forms, the one or more camera slots 269 may be provided along superior and inferior edges of the anterior wall 280 and configured to retain the top and bottom of the camera 220. The camera slots 269 may be sized and spaced appropriately to be able to retain one or more widely used models of smartphone, for example.

The anterior wall 280 may comprise an anterior wall gap 281, which is a void in the area of the anterior wall 280. When positioned in the camera retaining structure 268, the camera 220 may fill the anterior wall gap 281 so as to form the anterior wall 280 with other portions of the anterior wall 280 around the anterior wall gap 281. As is the case for the example of Figures 6A to 6D, the camera 220 may account for a significant portion of the area of the anterior wall 280 when in position. One advantage of the

anterior wall gap 281 is that it provides a user with access to an anterior side of the camera 220. If a user interface or control buttons of the camera 220 are positioned on its anterior side, the anterior wall gap 281 allows the user to operate the camera 220 while the camera is retained in position. If the camera 220 has a display screen 211, anterior wall gap 281 allows viewing of the display screen 211 while the camera 220 is retained in the camera retaining structure 268. That is, the device 200 may be configured so that the camera 220 of the second portable electronic device is inside the light-controlled environment and the second display screen 211 of the second portable electronic device is outside the light-controlled environment.

As shown in Figures 6A and 6C, one of the camera slots 269 may comprise a slot opening 292 in a posterior wall of the camera slot 269. The slot opening 292 may be positioned and sized appropriately so that, when a camera 220 is retained in the camera retaining structure 268, the lens of the camera 220 is positioned adjacent the slot opening 292 so that light can pass into the camera 220 through the opening. The slot opening 292 may be positioned appropriately for widely used models of smartphone, for example.

As shown in Figures 6B and 6D, the posterior wall 282 of the housing 262 may comprise the aperture 270, described in more detail above. The aperture 270 may be located in posterior wall 282 so that it is substantially directly opposite camera 220 when the camera 220 is retained by the camera retaining structure 268. In the example of the figures, the aperture 270 is positioned proximate one end of the posterior wall 282 and substantially directly opposite the slot opening 292 in the anterior wall 280.

In certain forms, the anterior wall 280 and the posterior wall 282 are substantially parallel to each other and, when the eye tracking device 200 is in use, may be oriented substantially parallel to the coronal (or frontal) plane of the body.

In certain forms, the display screen retaining structure 266 is comprised by the housing so that the display screen 210 is held adjacent to, or so as to form part of another wall, for example the posterior wall 282, the superior wall 288 or the inferior wall 290. In the example of Figures 6A to 6D, the posterior wall 282 comprises the display screen retaining structure 266. In this example, the posterior wall 282 comprises first and second posterior wall portions 282a and 282b with the first posterior wall portion 282a being located superior to the second posterior wall portion 282b during use, although in other forms the first posterior wall portion 282a may be inferior to the second posterior wall portion 282b

during use. The second posterior wall portion 282b may comprise the aperture 270 and be oriented substantially parallel to the anterior wall 280, as described above. The first wall portion 282a may be oriented at a non-zero angle to the second posterior wall portion 282b. Furthermore, the first wall portion 282a may comprise the display screen retaining structure 266. Consequently, in certain forms, the display screen retaining structure 266 retains the display screen 210 at the desired angle, for example the angle shown schematically in Figure 3.

In certain forms, for example as shown in Figures 6A and 6C, the display screen retaining structure 266 may comprise one or more display screen slots 267 into which the display screen 210 may be slid into in order to position the display screen 210 appropriately in the housing 262. In the form shown, the display screen retaining structure 266 comprises a display screen slot 267 along opposing lateral sides of the first posterior wall portion 282a to retain each end of the display screen 210 when the display screen is slid into the display screen slots 267. In other forms, the one or more display screen slots 267 may be provided along superior and inferior edges of the first posterior wall portion 282a and configured to retain the top and bottom of the display screen 210. The display screen slots 267 may be sized and spaced appropriately to be able to retain one or more widely used models of smartphone, for example.

The first posterior wall portion 282a may comprise a posterior wall gap 283, which is a void in the area of the posterior wall 282. When positioned in the display screen retaining structure 266, the display screen 210 may fill the posterior wall gap 283 so as to form the first posterior wall portion 282a with other portions of the first posterior wall portion 282a around the posterior wall gap 283. As is the case for the example of Figures 6A to 6D, the display screen 210 may account for a significant portion of the area of the first posterior wall portion 282 when in position.

In other forms, the display screen 210 may be held adjacent one of the other walls, for example the superior wall 288 or the inferior wall 290. In such forms, the respective wall comprises the display screen retaining structure 266 and may alternatively comprise first and second wall portions, similarly to the manner explained above in relation to the posterior wall 282.

The housing 262 may also comprise a reflector retaining structure 264 to retain the reflector 230 in the position explained earlier. The reflector retaining structure 264 may be formed on the internal side(s) of one or more walls of the housing 262. Alternatively, the reflector 230 may be retained in position by virtue of abutting the internal side(s) of the one or more of the walls of the housing 262. For example, in

the example of Figures 6A to 6D, the reflector 230 may be positioned inside the housing with a superior edge of the reflector abutting against the inferior-facing inner surface of the superior wall 288 and the inferior edge of the reflector abutting against the superior-facing inner surface of the inferior wall 290.

5 In certain forms, the housing 262 may comprise a first housing part 263a and a second housing part 263b. The first and second housing parts 263a and 263b may be configured to be assembled together to form the housing 262. In different forms of the technology, different combinations of the anterior wall 280, posterior wall 282, first side wall 284, second side wall 286, superior wall 288 and inferior wall 290 may be comprised by the first and second housing parts.

10

For example, in the form of the technology shown in Figures 6A to 6D, the first housing part 263a comprises the anterior wall 280, part of the first side wall 284, part of the second side wall 286, the first posterior wall portion 282a and the superior wall 288 while the second housing part 263b comprises the second posterior wall portion 282b, another part of the first side wall 284, another part of the second
15 side wall 286 and the inferior wall 290. Other forms of the technology have different arrangements. In some forms, the housing parts may be configured so that removal of the first housing part 263a from the second housing part 263b makes it possible, or easier, to insert the camera 220 into the camera slot 269 and/or to insert the display screen 210 into the display screen slot 267. Being able to separate the first and second housing parts may also facilitate cleaning the eye tracking device 200 and facilitate
20 manufacturing the device 220, for example the two housing parts may be designed to be conveniently moulded.

The form of the technology illustrated in Figures 10A and 10B is an example of a device 200 in which the frame 260 is configured to allow the display screen 210 and the camera 230 to be oriented
25 perpendicularly to each other, i.e. with the camera 220 positioned such that its optical axis is substantially parallel to the plane of the display screen 210. In this form, the frame 260 comprises a display screen retaining structure 266 and a camera retaining structure 268 (not shown) configured to position the display screen 210 and camera 220 in the stated orientations. In some forms, the frame 260 may comprise a housing 262 having a camera slot for holding the camera 220 and a display screen slot
30 for holding the display screen 210, such as described above. In other forms, other suitable mechanisms for positioning the display screen 210 and the camera 220 in the described orientations and positions may be used.

The schematic layout of light sources 350 relative to the eye 101 that is shown in Figure 8A may be achieved in the exemplary form of Figures 6A to 6D by positioning light sources 350 on an anterior-facing (i.e. interior) surface of posterior wall portion 282b either side of aperture 270. In another form, the light sources 350 may be placed on an inner side of the first side wall 284 and an inner side of the second side wall 286. In some forms, such as in the examples shown in Figures 10A and 10B, the one or more light sources 350 may be housed within an illumination unit 354. The illumination unit 354 may be provided to the front side of the housing 262, i.e. the side proximal to the eye 101 during use, and in front of aperture 270. The illumination unit 354 may be configured so that the eye 101 looks through the illumination unit 354 to see the first display screen 210 reflected in the reflector 230. A side of the illumination unit 354 proximal to the eye 101 may comprise a further aperture. As illustrated in Figure 8B, the one or more light sources 350 may be positioned on one or more lateral sides of the illumination unit 354, for example one light source 350 on one side of the illumination unit 354 and one light source 350 on the other side of the illumination unit 354.

In some forms, for example as shown in Figures 10A and 10B, the device 200 may comprise an eyepiece 271 for assisting a user to position their eye 101 appropriately for looking through the aperture 270 in the housing 262. In addition, the eyepiece 271 may help position each eye that uses the device 200 in a similar position, which may make capturing and analysis of eye tracking data easier, e.g. leading to more consistent / comparable analysis. In the illustrated example, the eyepiece 271 is mounted in front of the illumination unit 354 (i.e. on the side of the illumination unit 354 facing towards the eye 101 during use) in such a way that the eye 101 can gaze through the eyepiece 271, through the illumination unit 354 and through the aperture 270 in the front of the housing 262. In other forms in which the device 200 does not include an illumination unit 354, the eyepiece 271 may be provided directly to the front side of the housing 262. The eyepiece may comprise one or more hoods 274, for example a right hood 274a and a left hood 274b. Each hood 274 may be shaped to abut against the region of the patient's face around the eye 101 so that the user can comfortably look into the device 200 while the hood shields ambient light from entering the housing 262 through the aperture 270. In some forms, for example as shown in Figure 10B, the eyepiece 271 may comprise an eyepiece frame 272 to which the one or more hoods 274 are mounted. The eyepiece frame 272 may be formed with one or more apertures in it through which the eye 101 gazes when using device 200. The hoods 274 may be mounted to the eyepiece frame 272 around respective apertures. In some forms, for example as shown in Figure 10B, the eyepiece 271 may comprise an opaque cover 276 to block light passing through one of the apertures in the eyepiece frame 272 and to prevent a user from seeing out of one of the eyes when using the device 200. This may assist

with ensuring that the user's vision is only through eye 101 (which gazes into the device 200) when using the device, and may also assist with helping the user know where to position their eyes. In some forms, eyepiece 271 may be able to be disconnected from the housing 262 (or from illumination unit 354, if present) and reconnected in an upside-down orientation. This has the effect of allowing the user's other eye to look into the device 200 and to block the vision of the user's other eye, consequently, allowing movement of the user's other eye to be tracked. Any suitable mechanism to temporarily connect the eyepiece to the rest of the device 200 may be used and, in one exemplary form, an arrangement of magnets / magnetic elements may be used to form a magnetic connection between the eyepiece 271 and the rest of the device 200. The magnets / magnetic elements may be arranged so as to ensure the eyepiece 271 connects in a desired orientation.

In some forms, the housing 262 may comprise one or more openings in addition to aperture 270 to allow cables to pass through the walls of the housing and connect to one or more of the components inside. The cables may be used for supplying power to electronic devices inside the housing 262 and/or enabling the transfer of data to/from such devices.

In certain forms, the housing 262 may take the form of a headset that is suitable for use to display Virtual Reality (VR) and/or Augmented Reality (AR) content to the user. For example, the display screen 210 may be configured to display other content to the user, which may be part of a VR or AR experience. In some forms, there may be an additional display screen positioned generally anterior to the patient, and anterior to the reflector 230 and configured to display content to the user in the manner of a VR device. In another form, the anterior region of the device 200 may be largely transparent, or containing voids, so that the user can see out to the ambient environment directly in front of them. When the display screen 210 displays images that is viewed by the user on reflection by the reflector 230, these images are viewed in addition to the ambient environment and enables the device 200 to act as an AR device. In such forms, the device 200 may further comprise a head mounting structure to position and stabilise the device 200 on the user's head, for example an arrangement of straps or other headgear members.

6.2.5. Binocular Variant

The forms of the technology illustrated in Figures 6A to 6D, 10A and 10B are suitable for tracking the movement of a single eye 101. Single eye movement tracking may be suitable for the assessment of

some medical conditions (e.g. concussion) while the assessment of other medical conditions may benefit from tracking the movement of both a patient's eyes simultaneously.

In certain forms of the technology, an eye tracking device 200 suitable for tracking the movement of two eyes simultaneously may be provided, for example as shown in Figure 11. Such a form may be referred to as a "binocular" or "stereo" variant of the device. In such forms, the device 200 may comprise a single display screen 210 and two reflectors 230, with each reflector 230 positioned to reflect light from the display screen 210 into a respective one of the patient's eyes 101. For example, the two reflectors 230 may be positioned side-by-side inside the housing 262 and be positioned to reflect light from the display screen 210 into a respective one of the eyes 101 so that one eye views the display screen 210 reflected in the first reflector and the other eye views the display screen 210 reflected in the second reflector. In some forms each eye may only be able to see respective parts of the display screen 210 and the display screen 210 may be configured to display two images, which may be positioned side-by-side on the display screen, so that each image is presented to one of the eyes. In some forms, the housing 262 may comprise an internal wall (not shown) to divide the interior volume of the housing 262 into two chambers. The internal wall may be opaque and configured so as to substantially prevent light transmission between the chambers.

Consistent with the earlier comments, the cameras 220a and 220b may each comprise a second display screen 211 to display images captured by the respective camera. Alternatively, or additionally, the cameras 220a and 220b are configured to transmit the images to another device or devices, which may itself / themselves comprise a display screen for displaying the images or a memory for storing the images for display elsewhere. The images may be transmitted through a wired or wireless connection, for example Bluetooth, WiFi, NFC or the like.

The eye tracking device 200 in this form may further comprise two cameras 220a and 220b, with each camera positioned to image a respective eye as the eye looks at the display screen 210. For example, as shown in Figure 11, the cameras 220a and 220b may be positioned side-by-side on a side of the housing 262 facing away from the eye 101 during use, with each camera having a view through a respective aperture in the anterior wall 280 of the housing 262. That is, the housing 262 may have formed in its anterior wall 280 two apertures, spaced laterally apart for each of two cameras 220a and 220b to image a respective eye through a respective one of the reflectors. In such forms, the device 200 may comprise two camera retaining structures, each positioning one of the cameras for imaging a respective eye as

described. Alternatively, the eye tracking device 200 may comprise a single camera 220 and the device 200 may further comprise an optical assembly configured to create an image of each eye on the same camera sensor. For example, the optical assembly may comprise a plurality of porro prisms, for example four porro prisms arranged similarly to a pair of binoculars. In other forms, the optical assembly may
5 comprise another arrangement of prisms, lenses and/or mirrors.

The eye tracking device 200 in the form of Figure 11, and similar binocular variants, may comprise a housing 262 with two apertures 270 (not shown in Figure 11) in a posterior wall 282 facing towards the user's eyes in use, with each aperture suitably positioned to be viewed through by a respective eye in
10 use, for example the apertures 270 may be laterally spaced apart in the posterior wall 282. Alternatively, the posterior wall 282 may have a single aperture 270 formed in it that is sufficiently large for both eyes to view through. In some forms, an illumination unit 354 such as has been described above may be provided to a front side of the housing 262. In some forms, an eyepiece 271 may be provided to a front
15 side of the housing 262 or illumination unit 354. The eyepiece 271 may comprise a frame 272 and one or more hoods 274 suitable for two eyes to gaze through. For example the frame 272 may have formed therein two apertures, each positioned in front of a respective eye when the device is being used. The device 200 may comprise a single hood 274 configured to abut against a region of the user's face surrounding both eyes during use as shown in Figure 11 so that the user can comfortably look into the device 200 while the hood shields ambient light from entering the housing 262. Alternatively, the device
20 may comprise two such hoods, each configured for abutting against a respective eye during use.

It should be understood that aspects of the eye tracking devices according to other forms of the technology may apply to the forms of eye tracking device configured to track the movement of two eyes simultaneously. For example, the camera(s) 220 may be configured to view the eye 101 through the
25 reflectors 230 similarly to the manners explained earlier. Other aspects of the earlier forms of the technology may also apply to this two-eye variant of the technology, even if not expressly stated.

6.3. Operation of Eye Tracking Device

30 In order to use an eye tracking device 200 according to forms of the technology, the reflector 230, display screen 210 and camera 220 are positioned in accordance with the description above and the eye 101 is positioned so that it views the display screen 210 and the camera 220 is able to image the eye at the same time. For example, in the case of an eye tracking device 200 comprising a housing 262 such as

shown in Figures 6A to 6D, the reflector 230 is inserted into the housing 262 and the display screen 210 and camera 220 are inserted into the respective display screen slot 267 and camera slot 269. For example, a smartphone may be inserted into each of the slots. The display screen and camera may be activated and the eye 101 presented to aperture 270.

5

The display screen 210 may be configured to display any suitable information to the eye 101 to facilitate assessment of eye tracking, for example one or more images, including a moving image. Any suitable image may be displayed and certain forms of the technology are not limited by the nature of the image displayed on the display screen 210. The nature of the image may be dependent on the medical

10 condition that is to be assessed by tracking movement of the eye. In one example, as shown in Figures 2, 7A and 7B, the display screen is generally plainly coloured with a target 303 moving around a motion path 305. The target 303 may be any icon, for example a dot. The motion path 305 may be elliptical, circular, sinusoidal, sawtooth or any other motion path considered suitable to test a patient's eye tracking. In the exemplary display screen 210 of Figure 7B, the position of target 303 is shown in

15 successive positions 303a, 303b, 303c, 303d over time along its motion path 305. The same figure also shows projections of that path over time on the X-axis and on the Y-axis. The elliptical motion path 305 of the target 303 in this example may cause the eye to move in both the X direction (corresponding to points 303a and 303c) and the Y direction (corresponding to points 303b and 303d) so as to exercise the eye's range of motion. In some examples, motion path 305 may be altered to be flat or off-axis for some

20 testing regimes. Repeated motion of the target 303 along the motion path 305 smoothly exercises the human eye/brain interface. The movements in the X and Y axis independently are sinusoidal in nature in the example shown, but may be modified to be a sawtooth wave or square wave in other examples. In some forms, the speed and amplitude of the motion of the target 303 on the display screen 210 may be altered over time to increase the cognitive stress and physiological demand on the subject. Increasing

25 the cognitive stress will increase the severity of any symptoms and, by speeding up the motion, a breaking point may be able to be determined. In some forms, the subject may be tested over a set of trials, and the speed of the motion of the target 303 may be progressively increased in each successive trial. In certain forms, the subject may be tested before any injury to establish a baseline performance of the subject (variability in performance is to be expected based on fatigue and other condition of the

30 subject).

One advantage of a display screen 210 in which a majority of the screen is evenly illuminated, for example with a light colour such as white, is that the display screen 210 provides a relatively large

diffuse source of illumination within the internal chamber of the housing 262 that illuminates the eye 101 for the camera 220 to capture images of the eye. This may enable adequate illumination to be achieved with relatively low levels of illumination per pixel on the display screen 210 because a large number of pixels on the display screen 210 are illuminated at the relatively low level, so the overall illumination may be sufficiently high. Avoiding the light source being a relatively small but bright source may also avoid dazzling light sensitive users.

In certain exemplary uses of the eye tracking device 200, the patient is asked to look at the target 305 and follow its movement with their gaze as it moves around display screen 210. The camera 220 captures information on how the eye 101 moves in response to this stimulus.

The eye tracking device 200 may be used to track the movement of one of the patient's eyes at a time. The eye to be assessed can be positioned suitably with respect to the eye tracking device 200 and, when the other eye is to be assessed, the other eye can be brought into position. In the case of the eye tracking device 200 shown in Figures 6A to 6D, the aperture 270 is positioned towards one end of the housing 262. This makes it convenient for the housing 262 to be positioned close to the patient's face with the eye 101 presented close to aperture 270 and the rest of the housing extending laterally away from the patient's nose, so that the nose may not interfere with the positioning of the housing. In this position, the display screen 210 may be positioned superior to the aperture 270, for example directly anterior to the patient's forehead. If the patient's other eye is to be assessed, the housing 262 may be inverted so that the other eye is presented close to the aperture 270 and the housing extends laterally away from the nose on the other side of the patient. In this position, the display screen 210 may be positioned inferior to the aperture 270, for example directly anterior to the patient's cheek. In fact, the eye tracking device 200 shown in Figures 6A to 6D may be used in any orientation, as rotated around an axis passing through the centre of the aperture 270.

In operation of another form of the technology, for example a device 200 such as shown in Figure 11 that may be referred to as a binocular version, although the device 200 may be configured for two eyes to be presented to the device at a time, eye tracking may only occur for one eye at a time. For example, the display screen 210 may be configured to initially display an image for eye tracking in a part of the screen that is visible by the first eye, and the respective camera captures image data of movement of the first eye. Subsequently, the display screen 210 may be configured to display an image for eye tracking in a part of the screen that is visible by the second eye, and the respective camera captures

image data of movement of the second eye. One advantage of using a binocular version to test eyes in this manner compared to using a monocular version on each eye is that the user does not have to change the position of the device when changing from tracking one eye to the other.

5 **6.4. Use of Eye Tracking Information**

Through use of the eye tracking device 200, information on the movement of the eye 101 in response to changing images on the first display screen 210, for example, movement of the target 305, may be captured. This information may be displayed on the second display screen 211, stored on a memory of
10 the camera 210, transmitted to another device, or any combination of these options. The information, if transmitted to another device, for example to a remote device, may be stored at the other device and/or displayed on a display screen.

Certain forms of the present technology are not limited by the type of information on movement of the
15 eye 101 that is obtained through use of eye tracking device 200.

Based on the information of the movement of the eye, one or more medical conditions may be examined assessed and/or diagnosed. Certain forms of the present technology are not limited by the nature of the assessment or the medical condition(s).

20

6.5. Other Remarks

Unless the context clearly requires otherwise, throughout the description and the claims, the words “comprise”, “comprising”, and the like, are to be construed in an inclusive sense as opposed to an
25 exclusive or exhaustive sense, that is to say, in the sense of “including, but not limited to”.

The entire disclosures of all applications, patents and publications cited above and below, if any, are herein incorporated by reference.

30 Reference to any prior art in this specification is not, and should not be taken as, an acknowledgement or any form of suggestion that that prior art forms part of the common general knowledge in the field of endeavour in any country in the world.

The technology may also be said broadly to consist in the parts, elements and features referred to or indicated in the specification of the application, individually or collectively, in any or all combinations of two or more of said parts, elements or features.

- 5 Where in the foregoing description reference has been made to integers or components having known equivalents thereof, those integers are herein incorporated as if individually set forth.

- It should be noted that various changes and modifications to the presently preferred embodiments described herein will be apparent to those skilled in the art. Such changes and modifications may be
10 made without departing from the spirit and scope of the technology and without diminishing its attendant advantages. It is therefore intended that such changes and modifications be included within the present technology.

7. CLAIMS

1. A device for tracking movement of an eye, the device comprising:
 - a reflector;
 - 5 a display screen positioned relative to the reflector such that, in use, the eye views the display screen reflected in the reflector; and
 - a camera for imaging the eye when the eye is viewing the display screen, wherein the camera is positioned to image the eye through the reflector.
- 10 2. A device as claimed in claim 1, wherein the reflector comprises an opening and the camera is positioned to image the eye through the opening in use.
3. A device as claimed in claim 1, wherein the reflector is semi-transparent and the device is configured so that the camera is able to image the eye through the reflector and the eye is able
15 to view the display screen reflected in the reflector.
4. A device as claimed in any one of claims 1-3, wherein the device is configured such that, when viewing the display screen, the eye substantially fills the field of view of the camera.
- 20 5. A device as claimed in any one of claims 1-4, wherein the device is configured so that, during use, the camera is positioned substantially directly anterior to the eye.
6. A device as claimed in any one of claims 1-4, wherein the device is configured such that the camera is positioned anterior and inferior to the eye during use.
25
7. A device as claimed in any one of claims 1-6, wherein the reflector has a reflective side configured to reflect light from the display screen towards the eye, and the reflective side is concave in at least one plane.
- 30 8. A device as claimed in any one of claims 1-7, wherein the device further comprises a frame configured to position the reflector, the display screen and the camera relative to the eye during use.

9. A device as claimed in claim 8, wherein the frame comprises a housing to house the reflector, the display screen and the camera in a light-controlled environment, the housing comprising an aperture for the eye to be presented to during use of the device.
- 5 10. A device as claimed in claim 9, wherein the housing substantially prevents ambient light from entering the light-controlled environment during use.
11. A device as claimed in any one of claims 1-10, wherein the device comprises one or more light sources.
- 10 12. A device as claimed in claim 11, wherein the one or more light sources comprise the display screen.
13. A device as claimed in claim 11 or 12, wherein the one or more light sources comprise one or more light sources separate to the display screen.
- 15 14. A device as claimed in any one of claims 11-13, wherein the one or more light sources are a source of diffuse light.
- 20 15. A device as claimed in any one of claims 11-14, wherein the one or more light sources are positioned to one or more sides of the eye during use.
16. A device as claimed in any one of claims 11-15, wherein the one or more light sources are adjustable in brightness.
- 25 17. A device as claimed in any one of claims 11-16, wherein the frequency of light produced by the one or more light sources is adjustable.
18. A device as claimed in any one of claims 1-17, wherein the display screen is comprised as part of a first portable electronic device.
- 30 19. A device as claimed in any one of claims 1-18, wherein the camera is comprised as part of a second portable electronic device.

20. A device as claimed in claim 19, wherein the display screen of the device for tracking movement of an eye is a first display screen and the second portable electronic device comprises a second display screen for displaying images captured by the camera.
- 5 21. A device as claimed in claim 20, wherein the device is configured so that the camera of the second portable electronic device is inside the light-controlled environment and the second display screen of the second portable electronic device is outside the light-controlled environment.
- 10 22. A device as claimed in any one of claims 1-21, wherein the camera is configured to store and/or transmit images captured by the camera for viewing and/or analysis remote from the device, eye and/or camera.
23. A device as claimed in any one of claims 1-22,
- 15 wherein the reflector is a first reflector and the device further comprises a second reflector,
- wherein the eye is a user's first eye and the user has a second eye,
- wherein the display screen is positioned relative to the first and second reflectors such that, in use, the first eye views the display screen reflected in the first reflector and the second
- 20 eye views the display screen reflected in the second reflector, and
- wherein the camera is a first camera and the device further comprises a second camera for imaging the second eye when the second eye is viewing the display screen, wherein the second camera is positioned to image the second eye through the second reflector.
- 25 24. A frame suitable for use in a device for tracking movement of an eye, the frame comprising:
- a reflector retaining structure to position a reflector;
- a display screen retaining structure to position a display screen relative to the reflector when the reflector is positioned in the reflector retaining structure such that, in use, the eye views the display screen reflected in the reflector; and
- 30 a camera retaining structure to position a camera for imaging the eye when the eye is viewing the display screen.

25. A frame as claimed in claim 24, wherein the camera retaining structure is configured to position the camera and the reflector retaining structure is configured to position the reflector such that, in use, the camera images the eye through the reflector.
- 5 26. A frame as claimed in claim 25, wherein the reflector comprises an opening and the camera is positioned to image the eye through the opening in use.
- 10 27. A frame as claimed in claim 25, wherein the reflector is semi-transparent and the device is configured so that the camera is able to image the eye through the reflector and the eye is able to view the display screen reflected in the reflector.
28. A frame as claimed in any one of claims 24-27, wherein the frame is configured such that, when viewing the display screen, the eye substantially fills the field of view of the camera.
- 15 29. A frame as claimed in any one of claims 24-28, wherein the frame comprises a housing to house the reflector, the display screen and the camera in a light-controlled environment, the housing comprising an aperture for the eye to be presented to during use of the device.
- 20 30. A frame as claimed in claim 29, wherein the housing substantially prevents ambient light from entering the light-controlled environment other than through the aperture.
- 25 31. A frame as claimed in any one of claims 29-30, wherein the camera is comprised as part of a portable electronic device, wherein the display screen of the device for tracking movement of an eye is a first display screen and the second portable electronic device comprises a second display screen for displaying images captured by the camera, and the housing is configured so that the camera retaining structure positions the camera of the portable electronic device inside the light-controlled environment and the second display screen of the portable electronic device is outside the light-controlled environment.
- 30 32. A frame as claimed in any one of claims 24-31, wherein the housing comprises a first housing part and a second housing part, wherein the first housing part and the second housing part are configured to be assembled together to form the housing.

33. A frame as claimed in claim 32, wherein the first housing part comprises the display screen retaining structure and the camera retaining structure, and the second housing part comprises the aperture.

5 34. A frame as claimed in any one of claims 24-33,
wherein the reflector retaining structure is a first reflector retaining structure and the reflector is a first reflector and the device further comprises a second reflector retaining structure to position a second reflector,
wherein the eye is a user's first eye and the user has a second eye,
10 wherein the display screen retaining structure positions the display screen relative to the first and second reflectors such that, in use, the first eye views the display screen reflected in the first reflector and the second eye views the display screen reflected in the second reflector, and
wherein the camera retaining structure is a first camera retaining structure and the
15 device further comprises a second camera retaining structure to position a second camera for imaging the second eye when the second eye is viewing the display screen

20 35. A frame as claimed in claim 34, wherein the second camera retaining structure is configured to position the second camera to image the second eye through the second reflector.