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(73) Octrooihouder(s):
Rabbit-eyes B.V. te ROTTERDAM

(72) Uitvinder(s):
Lennard Goedknegt te ROTTERDAM
Richard Mendes te PARAMARIBO (SR)
Alexander M. J. Spaans te ROTTERDAM

(74) Gemachtigde:
ir. J.C. Volmer c.s. te Rijswijk

(54) DISPLAY DEVICE

(57) The invention relates to a display device for displaying an image for a user having a visual impairment. The display device comprises a pixelated display, a processor, an eye-tracking system and a microlens array. The invention is also related to a method for displaying an image for a user having a visual impairment on a display device. The invention is further related to a processor for operating a display device adapted for displaying an image for a user having a visual impairment and a computer program for performing the method of the invention.

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Title: DISPLAY DEVICE

The current invention is related to a display device for displaying an image for a user having a visual impairment. The invention is also related to a method for displaying an image for a user having a visual impairment on a display device. The invention is further related to a processor for operating a display device adapted for displaying an image for a user having a visual impairment and a computer program for performing the method of the invention.

The world is digitalizing at a fast pace and life without electronic displays has become unimaginable. Smart devices that incorporate such electronic displays, such as mobile phones and tables, have changed the lives of many people and has enabled a new generation of workers to be productive in the workplace.

Some people experience visual impairments such as hyperopia, presbyopia and cataracts. A substantial portion of the population is at risk from suffering from visual impairments. For example, people from their mid-thirties onwards have an elevated risk of experiencing a visual impairment associated with old age.

These visual impairments make it more difficult to focus on objects such as on electronic displays. This inhibits these people in their day to day lives. The operating systems of some of these electronic displays have features to alleviate some of the problems associated with visual impairments. For example, a size, brightness and contrast may be adjusted in order to make an image easier viewable for a person. Other features include displaying text of an image in bold, changing the color pallet and using speech technology.

WO 2019/171342 discloses a digital display device to render an input image for viewing by a viewer having reduced visual acuity. The display device comprises a digital display medium comprising an array of pixels, a microlens array disposed relative to said digital display and a hardware processor operable to render an image on the digital display medium so to produce a designated image perception adjustment to at least partially address the viewer´s reduced visual acuity. A dimension of each microlens is selected to minimize a spot size on a retina of the viewer produced by the digital display medium.

A downside of the digital display device known in the art is that, when the user moves relative to the display device, the user observes the images from a different angle which has a negative impact on the viewing experience and reduces the ability of the user to view the image in focus.

The invention provides a display device for displaying an image for a user having a visual impairment which alleviates the abovementioned downside. The display device according to the invention is described in claim 1.

The display device according to the invention is adapted for displaying an image for a user having a visual impairment. The display device comprises a pixelated display which comprises an array of pixels. Each pixel of the pixelated display comprises a number of subpixels, for example three subpixels, for example red, green and blue subpixels. By allowing the subpixels to emit light with a certain intensity, the corresponding subpixel value, the pixel may appear to emit light of varying color. The pixelated display of the display device is operable to display the image to an eye of the user located at a viewing location relative to a position of the pixelated display.

The display device further comprises a processor for operating the pixels of the pixelated display to display the image on the pixelated display. For example, the processor may be a processor of a smart device, such as a smart phone or a smartwatch. The processor may also be a processor dedicated to the functioning of the display device. The processor is operable to store information on the eye of the user such as focal length of the eye and size of the eye or size of the pupil. For example, the display device, when turned on for the first time, may prompt the user to take a few tests to determine the focal length and the size of the eye of the user. It may also be possible to manually store and change the focal length and the size of the eye of the user. In embodiments the processor may be adapted to store additional information on the user, such as additional information on the visual impairment of the user. In an embodiment the processor may further be adapted to store information on various users. The processor may be adapted to recognize various users, for example by facial recognition, and load the correct stored focal length and eye size.

The display device further comprises an eye-tracking system adapted for determining changes in the viewing location of the eye of the user relative to the position of the pixelated display. The eye-tracking system may for example be integrated in a camera system of a smart phone or a virtual reality headset comprising the display device. The eye-tracking system may also be a dedicated eye-tracking system. The eye-tracking system may continuously monitor changes in the position of the eye of the user, or the eye-tracking system may monitor changes in the position of the eye of the user at regular, or even irregular, intervals for example at 2 second intervals, or at 5 second intervals.

The display device further comprises a microlens array provided on the pixelated display. The microlens array comprises microlenses that are arranged in a two-dimensional plane oriented parallel to the pixelated display. The microlens array covers, preferably completely covers, the pixelated display. The microlens array is configured to project light emitted by the pixelated display towards the eye of the user in the viewing location.

The display device according to the invention comprises an eye-tracking system adapted for determining changes in the viewing location of the eye of the user relative to the position of the pixelated display. The eye-tracking system tracks the position of the eyes of the user and thus the position of the head of the user relative to the display device. This allows the display device to determine when a viewing position of the user relative to the display device changes.

The processor determines values of subpixels of the pixelated display in order to render a corrected image which appears more in focus for a user with a visual impairment. The processor is adapted to determine the values of the subpixels of the pixelated display based on a location of a virtual image plane.

The location of the virtual image plane is related to the focal length of the eye of the user. If the user had perfect vision the virtual image plane would lie on the retina of the user or, alternatively, on the pixelated display. However, if the user does not have perfect vision the virtual image plane lies either in front of or behind of the retina of the user or, alternatively, in front of or behind of the pixelated display. Whether the location of the virtual image plane is assumed to be near the retina of the user or near the pixelated display depends on the methodology used by the processor to determine the values of the pixels. Either relative position may be used by the invention.

The processor is configured for determining a first location of the virtual image plane, which corresponds to a first viewing location of the eye of the user. The relative position of the virtual image plane may change if the relative position of the eye of the user changes with respect to the pixelated display. For example, the virtual image plane may move parallel to the pixelated display when the eye of the user moves parallel relative to the pixelate display. If the values of the subpixels of the display do not change accordingly the corrected image may appear less in focus to the user.

The first location of the virtual image plane is determined by the processor by comparing the focal length of the eye of the user to the first viewing location of the eye of the user. The focal length of the eye of the user is related to the visual impairment of the user. The focal length may be measured by conventional means and stored in the processor for use in the invention. The processor may also be configured for determining the focal length. For example the processor may determine from the focal length and the first viewing location whether a lens of the eye of the user projects a sharp image in a plane in front of or behind of the retina of the user. The location of this plane is the location of the virtual image plane. Alternatively the processor may determine from the focal length and the first viewing location whether a user may focus on a plane in front of or behind of the pixelated display. In this case the location of this plane is the location of the virtual image plane.

A virtual image is located on the virtual image plane. The virtual image corresponds to an image to be displayed on the pixelated display. For example, the virtual image may be a mirrored version of an image to be displayed on the display. The virtual image comprises virtual pixels which each have a corresponding virtual pixel value. The virtual pixel value determines the color of each virtual pixel. The virtual pixels are located on the virtual image plane.

The processor is configured for relating a subpixel of the pixelated display to a corresponding first virtual pixel of the virtual image plane. The processor may be determined to use a method, such as ray tracing, to determine a light path of a light ray emitted by the corresponding subpixel. The light path is determined between the corresponding subpixel, the microlens array, the retina of the eye of the user and the virtual image plane. The location on the virtual image plane where the light ray crosses the virtual image plane is the location of the first virtual pixel.

The processor is configured for determining a first value of the subpixel by comparing the value of the subpixel to the value of the first virtual pixel. The value of the first virtual pixel is determined by the virtual image. The processor is configured to operate the corresponding subpixel based on the respective first value determined for the subpixel when the eye of the user is in the first viewing location. By repeating these steps for each subpixel of the pixelated display an image may be displayed on the pixelated display that appears in focus for the user when the eye of the user is in the first viewing location.

The processor is configured for determining a change in viewing location of the eye of the user based on a change in viewing location detected by the eye-tracking system. When the user moves away from the first viewing location the image displayed on the pixelated display may no longer appear to be in focus to the user. Thus the image has to be corrected and the values of the subpixels of the pixelated display have to be corrected for the image to appear in focus in a second viewing location.

The second viewing location is determined by the processor based on a change in viewing location detected by the eye-tracking system. The second viewing location is different from the first viewing location. The processor is further configured for determining a corresponding second location of the virtual image plane based on the second viewing location or, equivalently, based on the change of the viewing location from the first viewing location. The virtual image plane is between the first location and the second location when the eye of the user is between the first viewing location and the second viewing location. The virtual image is located on the virtual image plane irrespective of if the virtual image plane is in the first location or the second location.

When the eye of the user is in the second viewing location the processor is configured to relate the corresponding subpixel to a second virtual pixel of the virtual image plane. The processor is further configured for determining a second value of the corresponding subpixel of the pixelated display by comparing the value of the corresponding subpixel to a value of the second virtual pixel.

The processor is configured to operate the corresponding subpixel of the display based on the respective second value when the eye of the user is in the second viewing location.

In an embodiment wherein these steps are repeated for each subpixel of the pixelated display an image may be displayed on the pixelated display that appears in focus for the user when the eye of the user is in the second viewing location. The display device thus has compensated the image displayed on the pixelated display for the new location of the eye of the user. The invention thus allows an image to be compensated when the user moves to a second viewing location.

By repeating the steps when the eye of the user moves to a third viewing location the image will continue to appear in focus as viewed from the third viewing location. The invention thus allows the image displayed on the pixelated display to appear in focus irrespective of the viewing location and irrespective of movement of the eye of the user relative to the pixelated display. Thus the viewing experience is not negatively affected by movement relative to the pixelated display.

In embodiments it is possible that more than one light path of a light ray emitted by the corresponding subpixel exists between the corresponding subpixel, the microlens array, the retina of the eye of the user and the virtual image plane. In these embodiments one subpixel may correspond to multiple virtual subpixels. In these embodiments the value of the subpixel may be determined based on the first light path considered by the processor. In other embodiments the value of the subpixel may be determined based on the values of multiple virtual subpixels, e.g. based on an average value of the multiple subpixels.

A downside of determining which virtual pixel corresponds to a subpixel of the pixelated display for a given viewing location by determining a light path, e.g. by ray tracing, between the pixelated display and the virtual image plane is that this computation may be computationally intensive. As a result of this the corrected image displayed on the pixelated display may correct itself slower than desired. This may negatively impact the experience of the user. This problem may be larger if the pixelated display comprises more pixels and subpixels.

A known solution to this problem is to increase the computational power of the pixelated display and/or the corresponding smart device. However, this is limited by the hardware and other functionalities of the pixelated display and/or the smart device.

This problem is also present when a user moves to a second viewing location. In this case a second virtual pixel is to be determined that corresponds to the corresponding subpixel as the user is in the second viewing location. Determining the second virtual pixel for each subpixel of the display may be computationally intensive and require a lot of processor power. This may lead to a slower device and possible to an image that is corrected slower than desired.

This problem is alleviated by the display device according to claim 2. In this embodiment the processor is configured for relating the corresponding subpixel to the second virtual pixel of the virtual image plane by:

- determining, when the virtual image plane is in the first location, a first pixel location relative to the pixelated display of the corresponding first virtual pixel;
- comparing, when the virtual image plane is in the second location and for one or more of the virtual pixels, a location of the virtual pixels to the first pixel location; and

- relating the corresponding subpixel of the pixelated display to the virtual pixel whose location corresponds to the first pixel location when the virtual image plane is in the second location.

In this embodiment the second virtual pixel is determined by first determining a first pixel location of the first virtual pixel, second by comparing this first pixel location to locations of virtual pixels of the virtual image plane in the second location and third by relating the subpixel of the pixelate display to the virtual pixel whose location corresponds to the first pixel location.

For example, if the virtual image plane is shifted in a plane parallel to the pixelated display, such that the distance between the plane and the retina plane perpendicular to the pixelated display does not change, the virtual pixel whose second location corresponds to the first location of the first virtual pixel may be the virtual pixel whose second location is the first location.

For example, if the virtual image plane is moved in a direction perpendicular to the pixelated display, the virtual pixel whose second location corresponds to the first location of the first virtual pixel may be the pixel whose second location lies in the light path of the first virtual pixel.

Advantageously, in this embodiment it is not necessary to recalculate light paths of light rays emitted by the subpixels of the pixelate display. This reduces computational intensity significantly. As a result the display device may determine a corrected image faster so that the user experience is not affected negatively.

In an embodiment the processor is configured for determining:
- a parallel component of the first pixel location parallel to the pixelated display;
- a perpendicular component of the first pixel location perpendicular to the pixelated display;
- parallel components of the locations of each of the virtual pixels when the virtual image plane is in the second location; and
- perpendicular components of the locations of each of the virtual pixels when the virtual image plane is in the second location, and

wherein the processor is configured for, when the perpendicular components are equal, relating the corresponding subpixel of the pixelated display to the virtual pixel whose parallel component is equal to the parallel component of the first pixel location.

Any location may be decomposed relative to the pixelated display in a coordinate component that is perpendicular to the pixelated display and a coordinate component that is parallel to the pixelated display. For example in a so called Cartesian coordinate decomposition. The system may also use other types of coordinate system such as polar coordinate systems.

When the perpendicular component of the first pixel location and the perpendicular components of the location of one of the virtual pixels are equal, when the virtual image plane is in the second location, the first virtual pixel and the respective virtual pixel are corresponding virtual pixels if the parallel components are the same.

In an embodiment the processor is configured for relating the corresponding subpixel of the pixelated display to the virtual pixel whose parallel component is equal to the parallel component of the first pixel location when the eye-tracking system does not detect a change of the eye of the user in a perpendicular direction relative to the pixelated display.

The processor may determine that the perpendicular component of the first virtual pixel location and the perpendicular components of the locations of each of the virtual pixels, in the second location, are equal when the eye-tracking system does not detect a change in position in a direction perpendicular to the pixelated display. Thus in this embodiment the processor may not have to compare the perpendicular components directly, saving computational time.

In an embodiment the display device is adapted to provide a feedback, e.g. a haptic feedback, to the user, e.g. prompting the user to change the position of the pixelated display. For example, the system may provide a feedback when the user moves too far away or too close to the pixelated display for example such that the display device cannot properly render an image that appears in focus for the user. In another example, a feedback may be provided to a user prompting the user to keep the display device stable.

In an embodiment the eye-tracking system is further adapted for tracking a gaze of the eye of the user for determining at which part of the pixelated display the user is gazing. In display devices, in particular in display devices with larger displays, the user is often not focused on the entire display but rather at a part of the display. It may therefore be advantageous to not correct an image on the entire display but rather only part of the image where the user is gazing. Additionally tracking a gaze of the user may provide information on if the user is gazing at the display at all. In some examples the user may not be gazing at the display, and no image correction needs to take place.

In a further embodiment the corresponding subpixel is located in the part of the pixelated display at which the user is gazing. In this embodiment the image is corrected in the part of the pixelated display where the user is gazing. In particular, in an embodiment the processor is configured for relating each subpixel in the part of the pixelated display where the user is gazing to a corresponding first virtual pixel and to a corresponding second virtual pixel.

In an embodiment the display device is adapted for tracking a pupil size of a pupil of the eye of the user. For example, when the pupil size increases more information displayed on the pixelated display may fall into the eye of the user. Thus a larger portion of the image may need to be corrected. The pupil size of the user may be influenced by adjusting brightness of the display, e.g. at night.

In an embodiment of the display device the microlens width and/or the microlens height is equal or smaller than a pitch of 8 subpixels of the pixelated display. A smaller lens size may lead to a sharper image with less distortion effects due to the lenses. Advantageously the lens size is such that a moiré effect is avoided, for example wherein the moiré effect may be avoided when the lens size is not three times the pitch of the subpixels.

In an embodiment the display device is further provided with an optical gap layer, which is provided between the pixelated display and the microlens array, wherein the optical gap layer defines an optical gap between the pixelated display and the microlens array. The optical gap layer allows to increase or decrease the incidence angle of a light ray emitted by a subpixel of the display with the microlenses. A decrease of the incidence angle may be achieved by increasing the size of the optical gap. Similarly, an increase of the incidence angle may be achieved by decreasing the size of the optical gap.

In an embodiment the eye-tracking system is adapted for determining a viewing distance of the user relative to the pixelated display. This may be combined with a feedback system, when the viewing distance becomes too great or too small a feedback may be sent to the user to urge the user to change the viewing distance. Keeping the display device at a preferred viewing distance may increase the focus of the image as observed by the user. Additionally keeping the display device at a preferred distance may increase the amount of information observed by the user because, e.g. a larger portion of the display may be observed by the user.

In an embodiment wherein an optical gap layer is present a refractive index of the microlenses of the microlens array is higher than a refractive index of the optical gap layer.

In an embodiment, wherein an optical gap layer is present, for each lens of the microlens array, the relation:

smaller (microlens width, microlens height) / optical gap –
pupil diameter – point projection diameter) / object distance

is minimized,wherein the smaller of the corresponding microlens width and microlens height is denoted by smaller(microlens width, microlens height), an estimate for the pupil size of the user is denote by pupil diameter, a size of a projection of an arbitrary point within a subpixel on the plane in which the pupil of the eye lies is denoted by point projection diameter, and a distance from the pixelated display to the eye of the user is denoted by object distance.

The above relation, when the value is smaller but greater or equal to zero, allows for a larger number of subpixels to be projected onto the retina of the user compared to when the relation gives a larger number. A result is that the user views the pixelated display, not only in focus, but also with a higher resolution.

The microlens width, microlens height, and optical gap may all be determined during construction of the display device. The pupil diameter of the user may be approximated based on ambient light conditions or it may be determined based on measurements of the eye of the user. The point projection diameter and the object distance depend on the distance of the eye of the user to the display device. Thus the relation may be minimized by changing the distance to the display. This determines an optimal viewing distance. The display device may provide feedback, e.g. haptic feedback, to the user in order to encourage the user to keep the display at the optimal viewing distance.

In an embodiment wherein an optical gap layer is present the focal length of the lenses in the microlens array is equal to the optical gap.

In an embodiment wherein an optical gap layer is present the optical gap comprises a secondary microlens array.

In an embodiment the microlenses are rectangular microlenses.

In an embodiment the microlenses are square microlenses. In an embodiment the microlenses are circular or ellipsoidal microlenses. In an embodiment the microlenses are hexagonal microlenses.

In an embodiment the display device further comprises a protection layer which is placed on top of the microlens array. The protection layer may comprise a plastic see through layer which is placed on top of the microlens array to protect the microlenses and the pixelated display e.g. against scratches and dirt.

In an embodiment the pixelated display is provided in a smart phone case. For example, the entire display device is integrated in a smart phone case. In this embodiment the pixelated display may be integrated in the smart phone case such that the pixelated display is located adjacent to or on top of a display of the smart phone. For example, the pixelated display may mirror the information on the display of the smart phone.

The invention is further related to a method for displaying an image for a user having a visual impairment wherein use is made of a display device according to the invention.

In an embodiment the method comprises:
- determining a first location of a virtual image plane by comparing the focal length of the eye of the user to the viewing location, wherein a virtual image is located on the virtual image plane which virtual image corresponds to an image to be display on the pixelated display, wherein the virtual image determines values of virtual pixels of the virtual image plane;

- relating a subpixel of the pixelated display to a corresponding first virtual pixel of the virtual image plane by determining between the corresponding subpixel, the microlens array, the retina of the eye of the user, and the first virtual pixel a light path of a light ray emitted by the corresponding subpixel;

- determining a first value of the corresponding subpixel of the pixelated display by comparing the value of the corresponding subpixel to the value of the first virtual pixel;

- operating the corresponding subpixel of the display based on the respective first value when the eye of the user is in the first viewing location;

- determining a second location of the virtual image plane, corresponding to a second viewing location of the eye of the user, based on a change in the viewing location of the eye of the user determined by the eye-tracking system;

- relating the corresponding subpixel of the pixelated display to a second virtual pixel of the virtual image plane when the virtual image plane is in the second location;

- determining a second value of the corresponding subpixel of the pixelated by comparing the value of the corresponding subpixel to a value of the second virtual pixel; and

- operating the corresponding subpixel of the display based on the second value when the eye of the user is in the second viewing location.

In an embodiment the method further comprises:
- determining a first pixel location relative to the pixelated display of the corresponding first virtual pixel with the virtual image plane in the first location;
- comparing, when the virtual image plane is in the second location and for one or more of the virtual pixels, a location of each of the virtual pixels to the first pixel location; and
- relating the corresponding subpixel of the pixelated display to the virtual pixel whose location corresponds to the first pixel location when the virtual image plane is in the second location.

In an embodiment the method comprises:
- providing a feedback, e.g. a haptic feedback, to the user, e.g. prompting the user to change the position of the pixelated display.

In an embodiment the method comprises:
- tracking the location of the eye of the user by the eye-tracking system in a direction perpendicular to the pixelated display;
- changing the first location of the virtual image plane based on a change in a location of the eye of the user in the direction perpendicular to the pixelated display.

In an embodiment the method comprises:
- tracking a gaze of the eye of the user by the eye-tracking system for determining at which part of the pixelated display the user is looking;
wherein the corresponding subpixel is located in the part of the pixelated display at which the user is gazing.

The invention is further related to a processor for operating a display device adapted for displaying an image for a user having a visual impairment according to the invention.

The invention is further related to a computer program for performing the method according to the invention.

The invention is further related to a smart phone case comprising a pixelated display according to the invention and adapted for operating the pixelated display according to the method of the invention.

The invention will now be described in a non-limiting way by reference to the accompanying drawings in which like parts are indicated by like reference symbols and in which:

Fig. 1 depicts a display device comprising a pixelated display;
Fig. 2 depicts a side view of a pixelated display covered by a microlens array;
Fig. 3 depicts a front view of a pixelated display schematically showing a number of pixels and subpixels;
Fig. 4 depicts a schematic view of a light path between the pixelated display and the virtual image plane behind the eye of the user;
Fig. 5 depicts a schematic view of a light path between the pixelated display, the eye of the user and the virtual image plane behind the pixelated display;
Fig. 6 depicts a schematic view of the eye of the user in a first viewing location and the eye of the user in a second viewing location;
Fig. 7 depicts a flow chart of the method for displaying an image on the pixelated display; and
Fig. 8 depicts a flow chart of a method for determining a second virtual pixel.

Figure 1 depicts a display device 1 comprising a pixelate display 3. The pixelated display 3 comprises a number of pixels 4 which are schematically shown in figure 1. By emitting light at certain frequencies the pixels 4 may render an image 2 on the pixelated display 4. Each pixel 4 of the pixelated display 3 comprises a number, for example three, subpixels 13 which are not shown in figure 1.

The display device 1 further comprises a processor 6 for operating the pixels 4, e.g. by operating the subpixels 13. By operating the pixels 4 the image 2 may be displayed on the pixelated display 3. The processor is further operable to store information on the eye 5 of the user such as the focal length of the eye 5 of the user, the size of the eye 5 of the user, or the size of the pupil of the eye 5. This information may then be used by the processor 6 to determine values for the pixels 4, e.g. for the subpixels 13, to render the image 2 in a way that appears sharp to the user having the visual impairment.

The display device 1 further comprises an eye tracking system 7 adapted for determining changes in the viewing location of the eye 5 of the user relative to the position of the pixelated display 3. In other words the eye tracking system 7 tracks movement of the eye 5 of the user relative to the pixelated display 3.

The display device 1 of figure 1 is depicted wherein the pixelated display 3, the processor 6 and the eye-tracking system 7 all form part of the same apparatus. This is not necessarily the case, for example the processor 6 may be in a different location and communicate with the eye-tracking system 7 and the pixelated display 3 remotely, e.g. via internet or Bluetooth.

Figure 2 depicts a side view of a pixelated display 3 covered by a microlens array 8. The microlens array 8 is separated from the pixelated display 3 by an optical gap layer 17 which defines an optical gap 18 between the pixelated display 3 and the microlens array.

The microlens array 8 comprises a number of microlenses 9. The microlenses 9 of figure 3 are depicted as plano-convex. However other types of microlenses 9 may be used. The microlenses 9 may vary in shape, microlens width and microlens height. In embodiments the focal length of the microlenses 9 is substantially equal to the optical gap layer 17 such that the pixelated display 3 lies at the focal length of the microlens array 8. In embodiments the microlens array 8 may be covered by a protection layer 19 such as a translucent plastic layer to protect the microlenses 9 from e.g. scratches and dust.

Fig. 3 depicts a front view of a pixelated display 3 schematically showing a number of pixels 4 and subpixels 13. Each pixel 4 of the pixelated display 3 in figure 3 comprises three subpixels 13. For example each subpixel corresponds to another color channel such as red, green and blue. By emitting light with different values from these subpixels 13 the pixels 4 may appear to emit light at any wavelength. Thus this allows an image 2 to be displayed on the pixelated display 3.

Figure 4 depicts a schematic view of a light path 15 between the pixelated display 3 and the virtual image plane 10 behind the eye 5 of the user. The pixelated display 3 comprises a pixel 4 which comprises a number of subpixels 13. One of the subpixels 13 emits a light ray which travels along the light path 15 through the microlens array 8 and towards the eye 5 of the user. The processor 6 determines the light path 15 from the pixelated display 3 through the eye 5 of the user to the virtual image plane 10 using a technique such as ray tracing.

The virtual image plane 10 comprises a number of virtual pixels 12 whose values are determined by a virtual image 11 which is placed on the virtual image plane 10. The location of the virtual image plane 10 is determined by the processor 6 by comparing the focal length of the eye 5 of the user to the location wherein the eye 5 is, e.g. the first viewing location.

The light path 15 crosses the virtual image plane 10 in one of the virtual pixels 12. This may determine which of the virtual pixels 12 is the first virtual pixel 14. The value of the first virtual pixel 14 determines a value of the corresponding subpixel 13 when the eye of the user 5 is in the corresponding viewing location, e.g. in the first viewing location.

By determining a light path 15 for multiple subpixels 13 a value of each of these subpixels is determined by corresponding first virtual pixels 14. In this way a corrected image 2 may be displayed on the pixelated display 3 by the display device 1 which appears in focus to the user, e.g. based on the focal length of the eye 5 of the user, e.g. which focal length is effected by the visual impairment of the user.

Figure 5 depicts a schematic view of a light path 15 between the pixelated display 3, the eye 5 of the user and the virtual image plane 10 which is located behind the pixelated display 3. This embodiment shows an alternative method of finding a first virtual pixel 14 corresponding to a subpixel 13.

In figure 5 the virtual image plane 10 is located behind the pixelated display 3. In this case a light path 15 is determined by the processor 6 from the virtual image plane 10, through the pixelated display 3 and the microlens array 8, to the eye 5 of the user. This allows a corresponding virtual pixel 12, e.g. a corresponding first virtual pixel 14 if the eye 5 of the user is in the first viewing location, to be found for each subpixel 13 of the pixelated display 3.

Figure 6 depicts a schematic view of the eye 5 of the user in a first viewing location and the eye 5’ of the user in a second viewing location. The change in location of the eye 5, 5’ has been detected by the eye-tracking system 7, and a second virtual pixel 16 is related to the corresponding subpixel 13 by the processor 6. In an embodiment of the invention the second virtual pixel 16 is related to the corresponding subpixel 13 by a light path 15’. The light path 15’ is between the subpixel 13 and the virtual image plane 10’ in the second location thereof.

The processor 6 is configured for determining a second value of the corresponding subpixel 13 of the pixelated display 3 by comparing the value of the corresponding subpixel 13 to a value of the second virtual pixel 16. The processor 6 is further configured to operate the corresponding subpixel 13 of the display 3 based on the second value when the eye 5' of the user is in the second viewing location.

In another embodiment the second virtual pixel 16 is not determined by relating the second virtual pixel 16 to the subpixel 13 by a light path 15'. In this embodiment a first pixel location of the first virtual pixel 12 is determined when the virtual image plane 10 is in the first location. A location of the virtual pixels 12 is compared to this first pixel location when the virtual image plane 10 is in the second location. The subpixel 13 of the display 3 is then related to the virtual pixel 16 whose location corresponds to the first pixel location when the virtual image plane 10' is in the second location.

Advantageously, in this embodiment it is not necessary to recalculate light paths 15' of light rays emitted by the subpixels 13 of the pixelate display. This reduces computational intensity significantly. As a result the display device 1 may determine a corrected image 2 faster so that the user experience is not affected negatively when the eye of the user moves relative to the pixelated display 3.

Figure 7 depicts a flow chart of the method for displaying an image 2 on the pixelated display 3. The first step 101 of the method is to determine a first location of the virtual image plane 10 by comparing the focal length of the eye 5 of the user to the viewing location. A virtual image 11 may be located on the virtual image plane 10. The virtual image 11 corresponds to an image 2 to be displayed on the pixelated display 3 and the virtual image 11 determines values of virtual pixels 12 of the virtual image plane 10.

The second step 102 of the method relates a subpixel 13 of the pixelated display 3 to a corresponding first virtual pixel 12 of the virtual image plane 10 by determining between the corresponding subpixel 13, the microlens array 8, the retina of the eye 5 of the user, and the first virtual pixel 14 a light path 15 of a light ray emitted by the corresponding subpixel.

The third step 103 of the method is determining a first value of the corresponding subpixel 13 of the pixelated display 3 by comparing the value of the corresponding subpixel 13 to the value of the first virtual pixel 14.

The fourth step 104 of the method is operating the corresponding subpixel 13 of the display 3 based on the respective first value when the eye 5 of the user is in the first viewing location.

The fifth step 105 of the method is detecting a change in location of the eye 5 of the user by the eye-tracking system 7.

The sixth step 106 of the method is determining a second location of the virtual image plane 10, corresponding to a second viewing location of the eye 5 of the user, based on the change in the viewing location of the eye 5 of the user determined by the eye-tracking system 7. Wherein the second viewing location of the eye 5 of the user is different from the first viewing location.

The seventh step 107 of the method is relating the corresponding subpixel 13 of the pixelated display to a second virtual pixel 16 of the virtual image plane 10 when the virtual image plane 10 is in the second location.

The eight step 108 of the method is determining a second value of the corresponding subpixel 13 of the pixelated display 3 by comparing the value of the corresponding subpixel 13 to a value of the second virtual pixel 16.

The ninth step 109 of the method is operating the corresponding subpixel 13 of the display 3 based on the second value when the eye 5 of the user is in the second viewing location.

This method the user to move relative to the display device 1 without the user having a negative impact on the viewing experience as a result of viewing the corrected image 2 from different angles. The user may experience a negative impact on the viewing experience because the ability of the user to view the image 2 in focus is reduced depending on the viewing angle.

In embodiments wherein method steps 107 - 109 are repeated for each subpixel 13 of the pixelated display 3 an image 2 may be displayed on the pixelated display 3 that appears in focus for the user when the eye 5 of the user is in the second viewing location. The display device 1 thus has compensated the image 2 displayed on the pixelated display 3 for the new location of the eye 5 of the user. The invention thus allows an image 2 to be compensated when the user moves to a second viewing location.

By repeating the method steps 105-109 when the eye 5 of the user moves to a third viewing location the image 2 will continue to appear in focus as viewed from the third viewing location. The invention thus allows the image 2 displayed on the pixelated display 3 to appear in focus irrespective of the viewing location and irrespective of movement of the eye 5 of the user relative to the pixelated display 3. Thus the viewing experience is not negatively affected by movement relative to the pixelated display 3.

Figure 8 depicts a flow chart of a method for determining a second virtual pixel 16 which may be performed while performing method steps 101-107. The first step 110 is determining a first pixel location relative to the pixelated display 3 of the corresponding first virtual pixel 14 when the virtual image plane 10 is in the first location.

The second method step 111 is determining a location of one or more of the virtual pixels 12 when the virtual image plane 10’ is in the second location.

The third method step 112 is comparing, when the virtual image plane 10’ is in the second location and for one or more of the virtual pixels 12, a location of each of the virtual pixels 12 to the first pixel location.

The fourth method step 113 is relating the corresponding subpixel 13 of the pixelated display 3 to the virtual pixel 16 whose location corresponds to the first pixel location when the virtual image plane 10’ is in the second location.

CONCLUSIES

1. Scherminrichting (1) ingericht voor het weergeven van een afbeelding (2) voor een gebruiker met een visuele beperking, waarbij de scherminrichting (1) omvat:

- een gepixeleerd scherm (3) met een array pixels (4) en waarbij het gepixeleerde scherm (3) bedienbaar is om de afbeelding (2) weer te geven naar een oog (5) van de gebruiker die zich op een kijklocatie ten opzichte van een positie van het gepixeleerde scherm (3) bevindt;
- een processor (6) voor het aansturen van de pixels (4) van het gepixeleerde scherm (3) om de afbeelding (2) op het gepixeleere scherm (3) weer te geven waarbij de processor (6) bedienbaar is om informatie over het oog (5) van de gebruiker op te slaan, zoals brandpuntsafstand van het oog;
- een oogvolgsysteem (7) ingericht voor het vaststellen van veranderingen in de kijklocatie van het oog (5) van de gebruiker te opzichte van de positie van het gepixeleerde scherm (3); en
- een microlensarray (8) die is aangebracht op het gepixeleerde scherm (3), waarbij de microlensarray (8) microlenzen (9) omvat die zijn aangebracht in een tweedimensionaal vlak dat parallel aan het gepixeleerde scherm (3) georiënteerd is, waarbij de microlensarray (8) het gepixeleerde scherm bedekt, bij voorkeur volledig bedekt, en waarbij de microlensarray (8) is ingericht om licht uitgezonden door het gepixeleerde scherm (3) naar het oog (5) van de gebruiker in te kijklocatie te projecteren,

waarbij de processor (6) is ingericht om een eerste locatie van een virtueel beeldvlak (10) te bepalen, die correspondeert met een eerste kijklocatie van het oog (5) van de gebruiker, door de brandpuntsafstand van het oog van de gebruiker te vergelijken met de eerste kijklocatie, waarbij een virtueel beeld op het virtuele beeldvlak (10) ligt, welk virtueel beeld (11) correspondeert met een beeld (2) dat op het gepixeleerde scherm (3) afgebeeld wordt, waarbij het virtuele beeld (11) waarden van virtuele pixels (12) van het virtuele beeldvlak (10) bepalen,

waarbij de processor (6) is ingericht om een subpixel (13) van het gepixeleerde scherm (3) te relateren aan een corresponderende eerste virtuele pixel (14) van het virtuele beeldvlak (10) door het vaststellen tussen de corresponderende subpixel (13), de microlensarray (8), het retina van het oog (5) van de gebruiker, en de eerste virtuele pixel (14) van een lichtpad (15) van een lichtstraal die door de corresponderende subpixel (13) is uitgezonden, waarbij de processor (6) verder is ingericht voor het vaststellen van een eerste waarde van de corresponderende subpixel (13) van het gepixeleerde scherm (3) door de waarde van de corresponderende subpixel (13) te vergelijken met de waarde van de eerste virtuele pixel (14),

waarbij de processor (6) is ingericht om de corresponderende subpixel (13) van het scherm (3) te aansturen gebaseerd op de respectieve eerste waarde wanneer het oog (5) van de gebruiker in de eerste kijklocatie is,

waarbij de processor (6) is ingericht voor het vaststellen van een tweede locatie van het virtuele beeldvlak (10), die correspondeert met een tweede kijklocatie van het oog (5) van de gebruiker, wanneer het oogvolgsysteem (7) een verandering in de kijklocatie van het oog (5) van de gebruiker van de eerste kijklocatie naar de tweede kijklocatie vaststelt,

waarbij de processor (6) is verder ingericht om de corresponderende subpixel (13) van het gepixeleerde scherm (3) te relateren aan een tweede virtuele pixel (16) van het virtuele beeldvlak (10) wanneer het virtuele beeldvlak (10) in de tweede locatie is,

waarbij de processor (6) is verder ingericht om een tweede waarde van de corresponderende subpixel (13) van het gepixeleerde scherm (3) te bepalen door het vergelijken van de waarde van de corresponderende subpixel (13) met een waarde van de tweede virtuele pixel (16); en

waarbij de processor (6) is ingericht om de corresponderende subpixel (13) van het scherm (3) te aansturen gebaseerd op de tweede waarde wanneer het oog (5) van de gebruiker zich in de tweede kijklocatie bevindt.

2. Scherminrichting (1) volgens conclusie 1, waarbij de processor (6) is ingericht om de corresponderende subpixel (13) te relateren aan de tweede virtuele pixel (16) van het virtuele beeldvlak (10) door:

- het vaststellen, wanneer het virtuele beeldvlak (10) in de eerste locatie is, van een eerste pixellocatie van de corresponderende eerste virtuele pixel (14) ten opzichte van het gepixeleerde scherm (3);
- het vergelijken, wanneer het virtuele beeldvlak (10) zich in de tweede locatie bevindt, en voor een of meer van de virtuele pixels (12), van een locatie van elk van de virtuele pixels (12) met de eerste pixellocatie; en

- het relateren van de corresponderende subpixel (13) van het gepixeleerde scherm (3) met de virtuele pixel (16) waarvan de locatie correspondeert met de eerste pixellocatie wanneer het virtuele beeldvlak (10) zich in de tweede locatie bevindt.

3. Scherminrichting volgens conclusie 2, waarbij de processor (6) is ingericht voor het bepalen van:
- een parallel component van de eerste pixellocatie die parallel is aan het gepixeleerde scherm (3);
- een loodrecht component van de eerste pixellocatie die loodrecht op het gepixeleerde scherm (3) is;
- parallelle componenten van de locaties van elk van de virtuele pixels (12) wanneer het virtuele beeldvlak (10) zich in de tweede locatie bevindt; en
- loodrechte componenten van de locaties van elk van de virtuele pixels (12) wanneer het virtuele beeldvlak (10) zich in de tweede locatie bevindt, en

waarbij de processor (6) is ingericht voor, wanneer de loodrechte componenten gelijk zijn, het relateren van de corresponderende subpixel (13) van het gepixeleerde scherm (3) met de virtuele pixel (16) waarvan de parallele component overeenkomt met de parallele component van de eerste pixellocatie.

4. Scherminrichting (1) volgens conclusie 3, waarbij de processor (6) is ingericht voor het relateren van de corresponderende subpixel (13) van het gepixeleerde scherm (3) met de virtuele pixel (16) waarvan de parallele component gelijk is aan de parallele component van de eerste pixellocatie wanneer het oogvolgsysteem (7) geen verandering in de locatie van het oog (5) van de gebruiker in een richting loodrecht op het gepixeleerde scherm (3) detecteert.

5. Scherminrichting (1) volgens een of meer van de voorgaande conclusies, waarbij de scherminrichting (1) is ingericht om feedback, bijvoorbeeld haptische feedback, te verschaffen aan de gebruiker, bijvoorbeeld om de gebruiker aan te zetten de locatie van het gepixeleerde scherm (3) te veranderen.

6. Scherminrichting (1) volgens een of meer van de voorgaande conclusies, waarbij het oogvolgsysteem (7) verder is ingericht om een blikveld van het oog (5) van de gebruiker te volgen voor het vaststellen naar welk deel van het gepixeleerde scherm (3) de gebruiker kijkt.

7. Scherminrichting (1) volgens conclusie 6, waarbij de corresponderende subpixel (13) in het deel van het gepixeleerde scherm (3) ligt waarnaar de gebruiker kijkt.

8. Scherminrichting (1) volgens een of meer van de voorgaande conclusies, waarbij een microlensbreedte en/of een microlenshoogte gelijk of kleiner is dan afstand van 8 subpixels (13) van het gepixeleerde scherm (3).

9. Scherminrichting (1) volgens een of meer van de voorgaande conclusies, waarbij de scherminrichting (1) verder is voorzien van een optische gatlaag (17), welke is aangebracht tussen het gepixeleerde scherm (3) en de microlensarray (8), waarbij de optische gatlaag (17) een optisch gat definieert tussen het gepixeleerde scherm en de microlensaarrray (8).

10. Scherminrichting (1) volgens conclusie 9, waarbij een optische gatlaag aanwezig is, waarbij voor elke lens van de microlensarray, de relatie:

kleiner(microlens breedte, microlens hoogte) / optische gat –
(pupildiameter – puntprojectiediameter) / objectafstand

geminimaliseerd is, waarbij de kleinere van de corresponderende microlensbreedte en microlenshoogte gegeven is door kleiner(microlens breedte, microlens hoogte), een schatting van de pupilgrootte van de gebruiker gegeven is door pupildiameter, een grootte van een projectie van een willekeurig punt in een subpixel op het vlak waarin het pupil van het oog ligt gegeven is door de puntprojectiediameter, en een afstand van het gepixeleerde scherm naar het oog van de gebruiker gegeven is door objectafstand.

11. Scherminrichting (1) volgens een of meer van de conclusies 9-10, waarbij de brandpuntsafstand van de microlenzen (9) in de microlensarray (8) gelijk is aan het optische gat (18).

12. Scherminrichting (1) volgens een of meer van de conclusies 9-11, waarbij het optische gat (18) een tweede microlensarray omvat.

13. Scherminrichting (1) volgens een of meer van de voorgaande conclusies, waarbij de microlenzen (9) rechthoekige microlenzen zijn (9).

14. Scherminrichting (1) volgens een of meer van de voorgaande conclusies, waarbij de microlenzen (9) vierkante microlenzen (9) zijn.

15. Scherminrichting (1) volgens een of meer van de voorgaande conclusies, waarbij de scherminrichting (1) verder een beschermingslaag (19) omvat welke bovenop de microlensarray (8) aangebracht is.

16. Scherminrichting (1) volgens een of meer van de voorgaande conclusies, waarbij het gepixeleerde scherm (3) is voorzien in een smart phone case.

17. Werkwijze voor het weergeven van een afbeelding (2) voor een gebruiker met een visuele beperking waarbij gebruik wordt gemaakt van een scherminrichting (1) volgens een of meer van de voorgaande conclusies.

18. Werkwijze volgens conclusie 17, waarbij de werkwijze omvat:
- het vaststellen van een eerste locatie van een virtueel beeldvlak (10) door het vergelijken van de brandpuntsafstand van een oog (5) van de gebruiker met de kijklocatie, waarbij een virtueel beeld (11) aanwezig is op het virtuele beeldvlak (10) welk virtueel beeld (11) correspondeert met een beeld (2) dat op het gepixeleerde scherm (3) afgebeeld wordt, waarbij het virtuele beeld (11) waarden van virtuele pixels (12) van het virtuele beeldvlak (10) bepaald;

- het relateren van een subpixel (13) van het gepixeleerde scherm (3) met een corresponderende eerste virtuele pixel (14) van het virtuele beeldvlak (10) door het bepalen tussen de corresponderende subpixel (13), de microlensarray (8), de retina van het oog van de gebruiker, en de eerste virtuele pixel (14) van een lichtpad (15) van een lichtstraat uitgezonden door de corresponderende subpixel (13);

- het bepalen van een eerste waarde van de corresponderende subpixel (13) van het gepixeleerde scherm (3) door het vergelijken van de waarde van de corresponderende subpixel (13) met de waarde van de eerste virtuele subpixel (14);

- het aansturen van de corresponderende subpixel (13) van het scherm (3) gebaseerd op de respectieve eerste waarde wanneer het oog (5) van de gebruiker zich in de eerste kijklocatie bevindt;

- het bepalen van een tweede locatie van het virtuele beeldvlak (10), die correspondeert met een tweede kijklocatie van het oog (5) van de gebruiker, gebaseerd op een verandering in de kijklocatie van het oog (5) van de gebruiker vastgesteld door het oogvolgsysteem (7);

- het relateren van de corresponderende subpixel (13) van het gepixeleerde scherm (3) met een tweede virtuele pixel (16) van het virtuele beeldvlak (10) wanneer het virtuele beeldvlak (10) zich in de tweede locatie bevindt;

- het bepalen van een tweede waarde van de corresponderende subpixel (13) van het gepixeleerde scherm (3) door het vergelijken van de waarde van de corresponderende subpixel (13) met een warde van de tweede virtuele pixel (16); en

- het aansturen van de corresponderende subpixel (13) van het scherm (3) gebaseerd op de tweede waarde wanneer het oog (5) van de gebruiker zich in de tweede kijklocatie bevindt.

19. Werkwijze volgens conclusie 18, waarbij de werkwijze verder omvat:
- het bepalen van een eerste pixellocatie ten opzichte van het gepixeeleerde scherm (3) van de corresponderende eerste virtuele pixel (14) wanneer het virtuele beeldvlak (10) zich in de eerste locatie bevindt;
- het vergelijken, wanneer het virtuele beeldvlak (10) zich in de tweede locatie bevindt en voor een of meer van de virtuele pixels (12), van een locatie van elk van de virtuele pixels (12) met de eerste pixellocatie; en
- het relateren van de corresponderende subpixel (13) van het gepixeleerde scherm (3) met de virtuele pixel (16) waarvan de locatie correspondeert met de eerste pixellocatie wanneer het virtuele beeldvlak (10) zich in de tweede locatie bevindt.

20. Werkwijze volgens een of meer van de conclusies 17-19, waarbij de werkwijze omvat:
- het verschaffen van feedback, bijvoorbeeld haptische feedback, aan de gebruiker, bijvoorbeeld om de gebruiker aan te zetten de locatie van het gepixeleerde scherm (3) te veranderen.

21. Werkwijze volgens een of meer van de conclusies 17-20, waarbij de werkwijze omvat:
- het volgen van de locatie van het oog (5) van de gebruiker door het oogvolgsysteem (7) in een richting loodrecht op het gepixeleerde scherm;
- het veranderen van de eerste locatie van het virtuele beeldvlak (10) gebaseerd op een verandering in een locatie van het oog (5) van de gebruiker in een richting loodrecht op het gepixeleerde scherm.

22. Werkwijze volgens een of meer van de conclusies 17-21, waarbij de werkwijze omvat:
- het volgen van een blik van het hoog (5) van de gebruiker door het oogvolgsysteem (7) voor het bepalen naar welk deel van het gepixeleerde scherm (3) de gebruiker kijkt;
waarbij de corresponderende subpixel (13) zich in het deel van het gepixeleerde scherm bevindt waarnaar de gebruiker kijkt.

23. Processor (6) voor het aansturen van een scherminrichting (1) die is ingericht voor het weergeven van een beeld (2) voor een gebruiker met een visuele beperking volgens een of meer van de conclusies 1-16.

24. Computerprogramma voor het uitvoeren van de werkwijze volgens conclusies 17-22.

25. Smart phone case omvattende een scherminrichting (1) volgens een of meer van de conclusies 1-16 en ingericht voor het aansturen van de scherminrichting (1) volgens de werkwijze volgens een of meer van de conclusies 17-22.

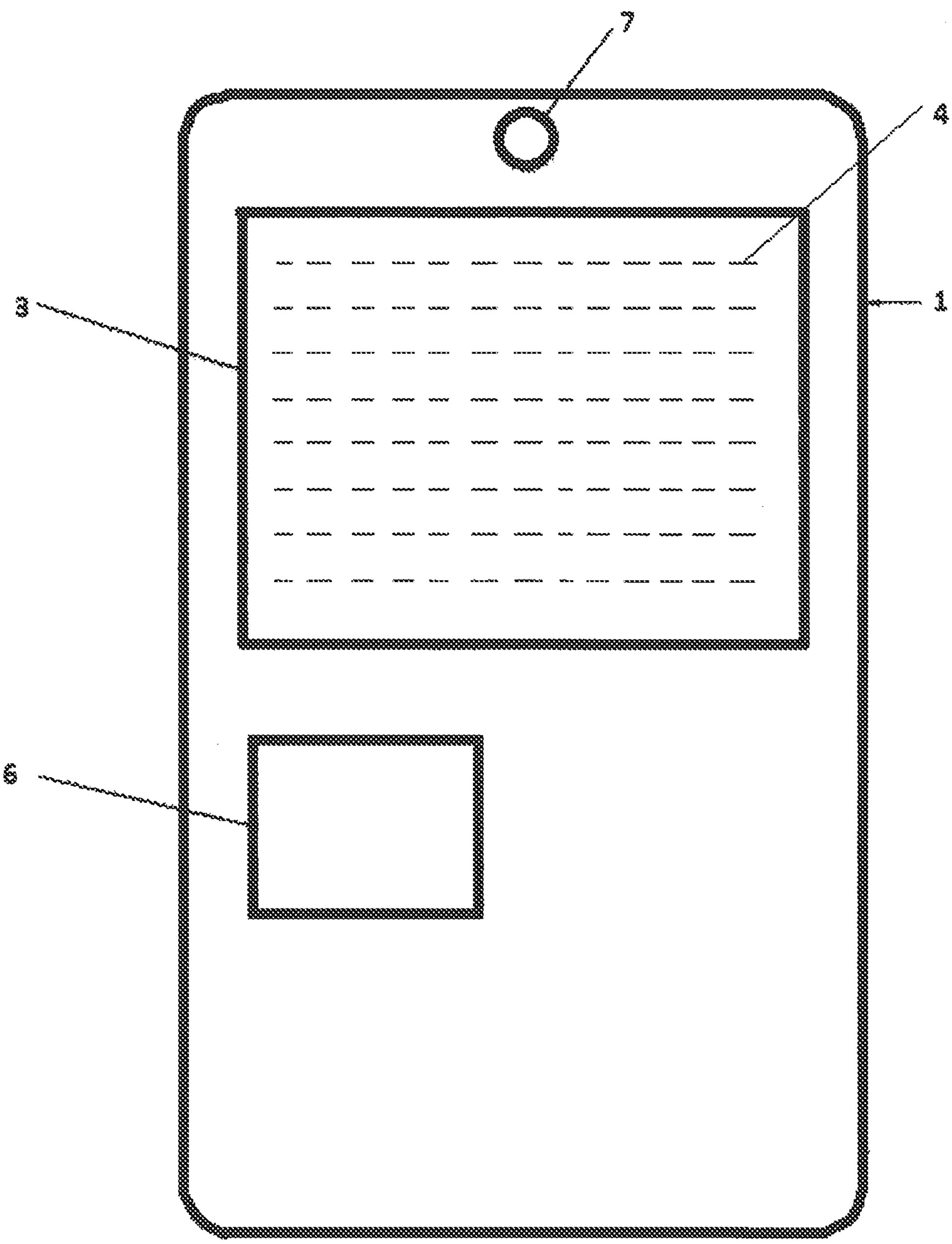

Fig. 1

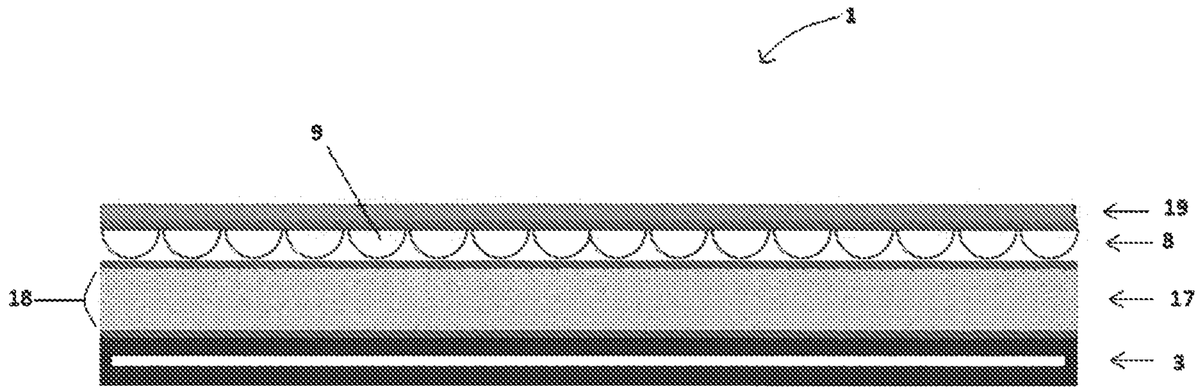

Fig. 2

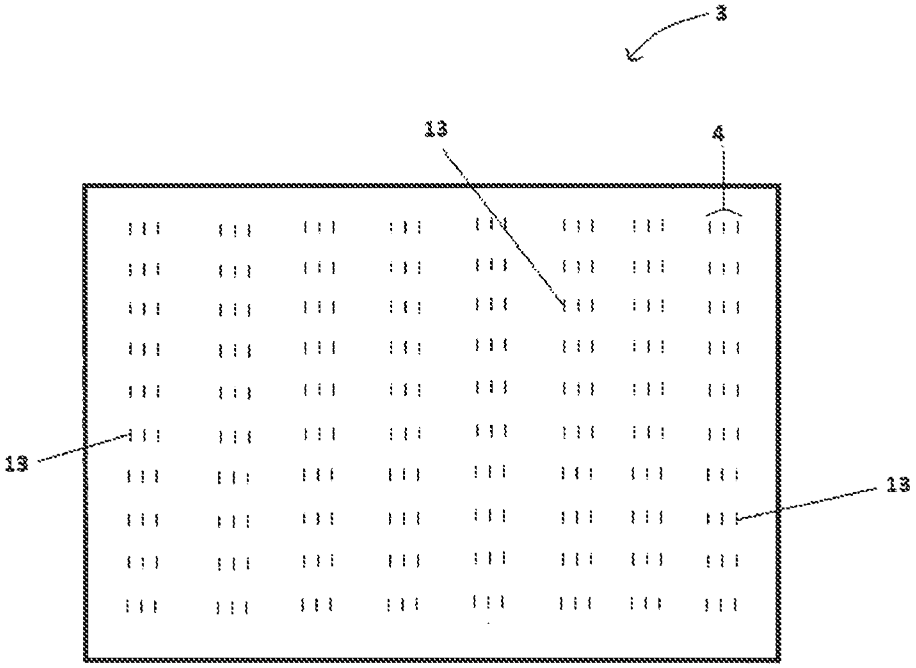

Fig. 3

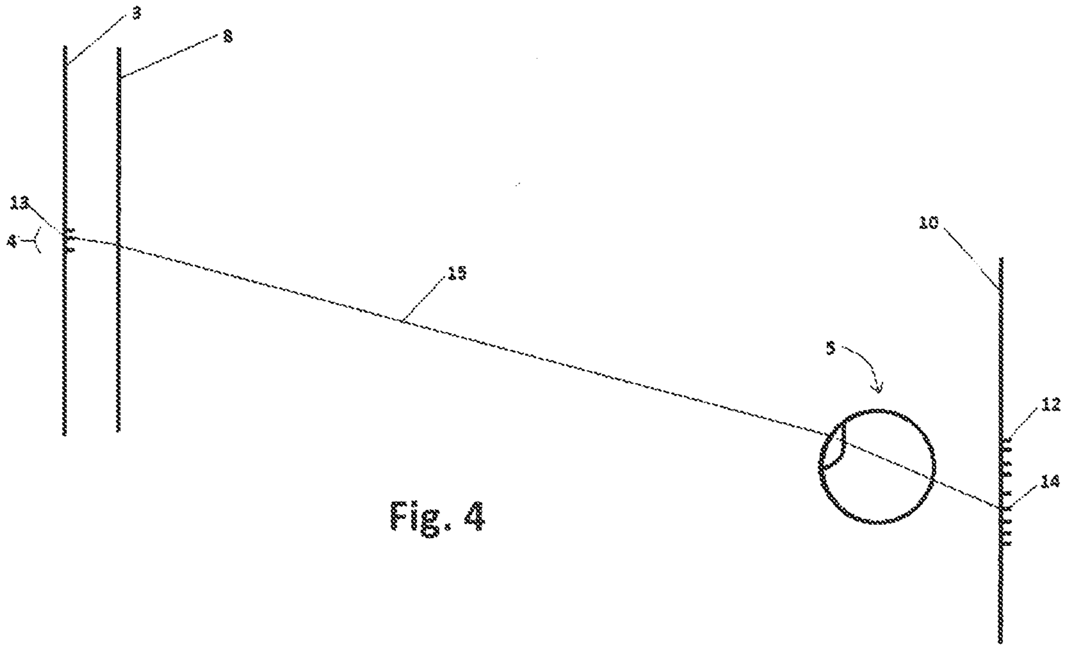

Fig. 4

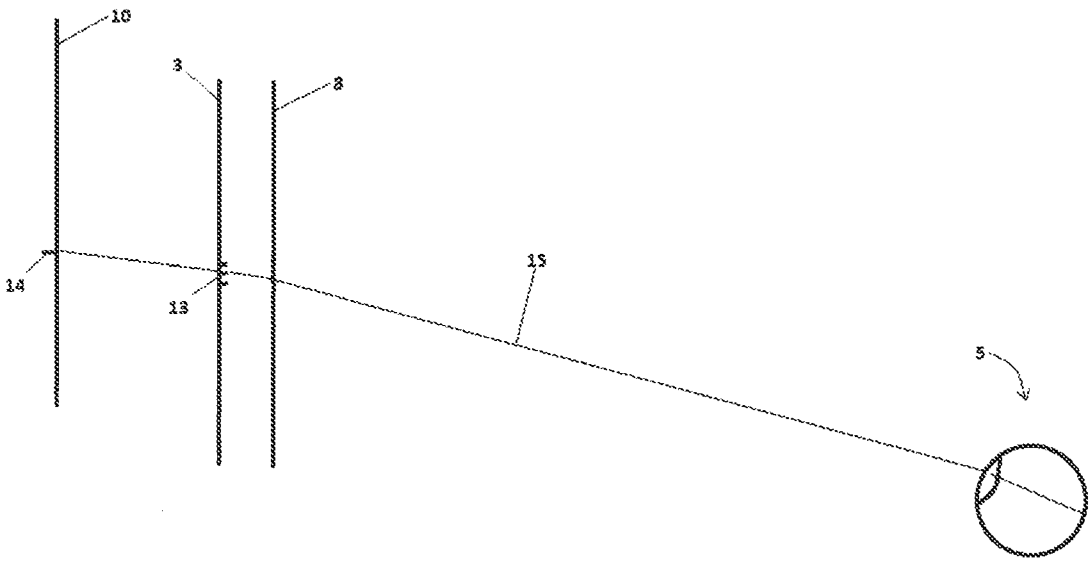

Fig. 5

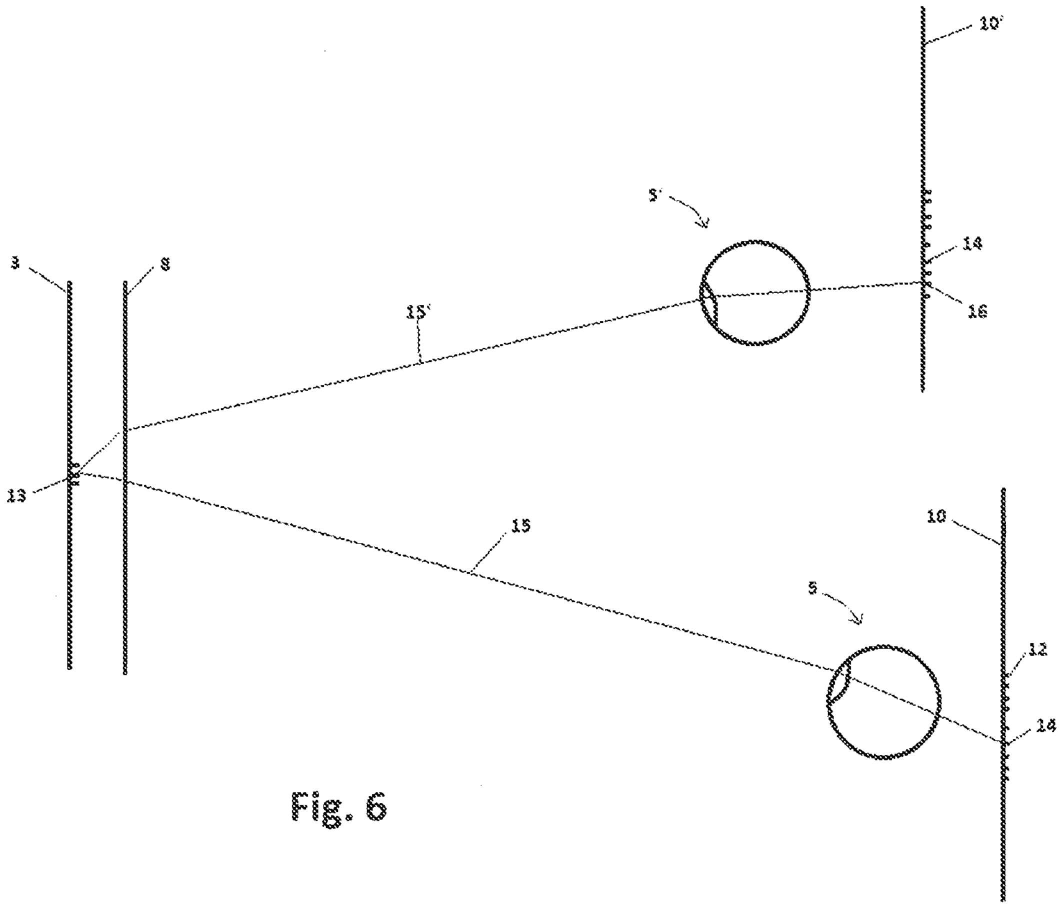

Fig. 6

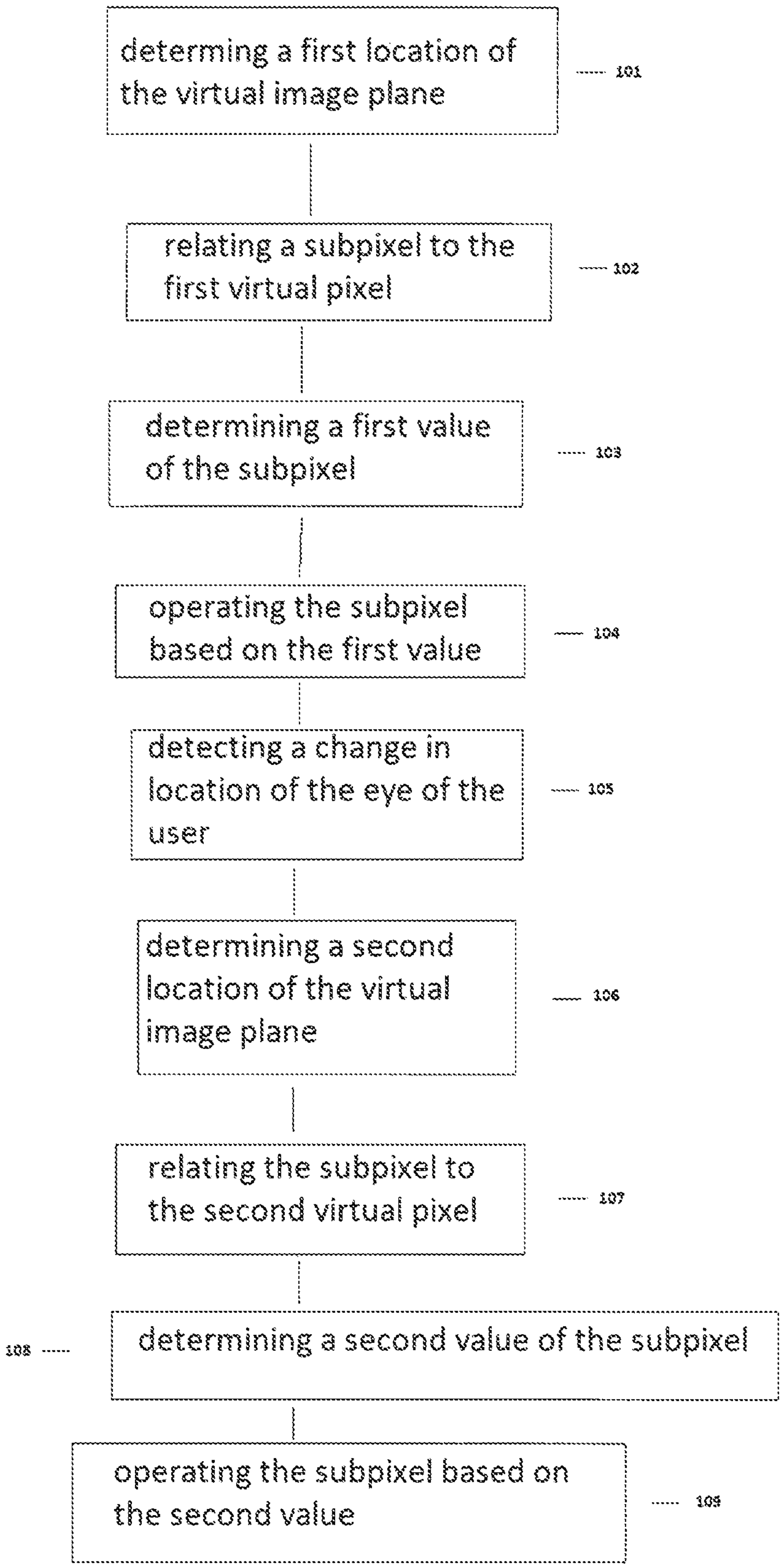
determing a first location of the virtual image plane
101
relating a subpixel to the first virtual pixel
102
determining a first value of the subpixel
103
operating the subpixel based on the first value
104
detecting a change in location of the eye of the user
105
determining a second location of the virtual image plane
106
relating the subpixel to the second virtual pixel
107
108
determining a second value of the subpixel
operating the subpixel based on the second value
109

Fig. 7

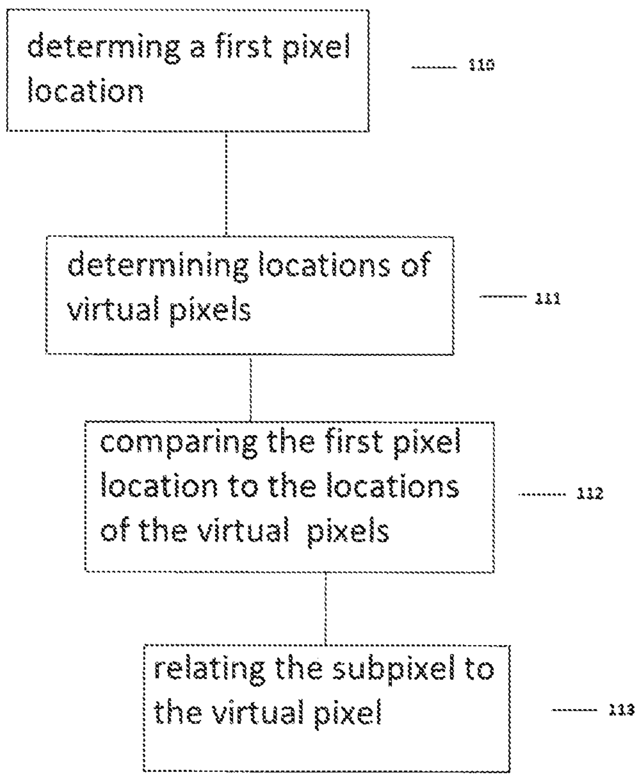
determing a first pixel location
110
determining locations of virtual pixels
111
comparing the first pixel location to the locations of the virtual pixels
112
relating the subpixel to the virtual pixel
113

Fig. 8

SAMENWERKINGSVERDRAG (PCT)

RAPPORT BETREFFENDE NIEUWHEIDSONDERZOEK VAN INTERNATIONAAL TYPE

IDENTIFICATIE VAN DE NATIONALE AANVRAGE	**KENMERK VAN DE AANVRAGER OF VAN DE GEMACHTIGDE**
Nederlands aanvraag nr. **2026709**	Indieningsdatum **20-10-2020**
	Ingeroepen voorrangsdatum
Aanvrager (Naam) **Rabbit-eyes B.V.**	
Datum van het verzoek voor een onderzoek van internationaal type **05-12-2020**	Door de Instantie voor Internationaal Onderzoek aan het verzoek voor een onderzoek van internationaal type toegekend nr. **SN77566**

I. CLASSIFICATIE VAN HET ONDERWERP (bij toepassing van verschillende classificaties, alle classificatiesymbolen opgeven)
Volgens de internationale classificatie (IPC) **Zie onderzoeksrapport**

II. ONDERZOCHTE GEBIEDEN VAN DE TECHNIEK	
	Onderzochte minimumdocumentatie
Classificatiesysteem	Classificatiesymbolen
IPC	**Zie onderzoeksrapport**
Onderzochte andere documentatie dan de minimum documentatie, voor zover dergelijke documenten in de onderzochte gebieden zijn opgenomen	

III.		**GEEN ONDERZOEK MOGELIJK VOOR BEPAALDE CONCLUSIES**	(opmerkingen op aanvullingsblad)
IV.		**GEBREK AAN EENHEID VAN UITVINDING**	(opmerkingen op aanvullingsblad)

Form PCT/ISA 201 A (11/2000)

ONDERZOEKSRAPPORT BETREFFENDE HET RESULTAAT VAN HET ONDERZOEK NAAR DE STAND VAN DE TECHNIEK VAN HET INTERNATIONALE TYPE

Nummer van het verzoek om een onderzoek naar de stand van de techniek
NL 2026709

A. CLASSIFICATIE VAN HET ONDERWERP
INV. G02B27/00 A61B3/00 A61B3/028 A61B3/11 A61B3/113
G02B30/27 G06F1/16 G06F3/01 G06F3/147 G06K9/00
G06K9/20 G02B30/30 G02F1/1335

Volgens de Internationale Classificatie van octrooien (IPC) of zowel volgens de nationale classificatie als volgens de IPC.

B. ONDERZOCHTE GEBIEDEN VAN DE TECHNIEK

Onderzochte mimimum documentatie (classificatie gevolgd door classificatiesymbolen)
G02B A61B G06T G06K G09G G06F G02F

Onderzochte andere documentatie dan de mimimum documentatie, voor dergelijke documenten, voor zover dergelijke documenten in de onderzochte gebieden zijn opgenomen

Tijdens het onderzoek geraadpleegde elektronische gegevensbestanden (naam van de gegevensbestanden en, waar uitvoerbaar, gebruikte trefwoorden)

EPO-Internal, WPI Data

C. VAN BELANG GEACHTE DOCUMENTEN

Categorie °	Geciteerde documenten, eventueel met aanduiding van speciaal van belang zijnde passages	Van belang voor conclusie nr.
A	US 2020/272232 A1 (LUSSIER GUILLAUME [CA] ET AL) 27 augustus 2020 (2020-08-27) * samenvatting * * Paragraphs [0002]-[0003], [0010]-[0011], [0110]-[0111], [0112], [0113]-[0115], [0119]-[0121], [0132]-[0135], [0139]-[0141] * * figuren 1-52 * -----	1-25
A	US 2015/262424 A1 (TABAKA COREY [US] ET AL) 17 september 2015 (2015-09-17) * samenvatting * * Paragraphs [0006]-[0008], [0082]-[0086], [0097]-[0102] * * figuren 1-7 * -----	1-25

☐ Verdere documenten worden vermeld in het vervolg van vak C.

☒ Leden van dezelfde octrooifamilie zijn vermeld in een bijlage

° Speciale categorieën van aangehaalde documenten

"A" niet tot de categorie X of Y behorende literatuur die de stand van de techniek beschrijft

"D" in de octrooiaanvrage vermeld

"E" eerdere octrooi(aanvrage), gepubliceerd op of na de indieningsdatum, waarin dezelfde uitvinding wordt beschreven

"L" om andere redenen vermelde literatuur

"O" niet-schriftelijke stand van de techniek

"P" tussen de voorrangsdatum en de indieningsdatum gepubliceerde literatuur

"T" na de indieningsdatum of de voorrangsdatum gepubliceerde literatuur die niet bezwarend is voor de octrooiaanvrage, maar wordt vermeld ter verheldering van de theorie of het principe dat ten grondslag ligt aan de uitvinding

"X" de conclusie wordt als niet nieuw of niet inventief beschouwd ten opzichte van deze literatuur

"Y" de conclusie wordt als niet inventief beschouwd ten opzichte van de combinatie van deze literatuur met andere geciteerde literatuur van dezelfde categorie, waarbij de combinatie voor de vakman voor de hand liggend wordt geacht

"&" lid van dezelfde octrooifamilie of overeenkomstige octrooipublicatie

Datum waarop het onderzoek naar de stand van de techniek van internationaal type werd voltooid	Verzenddatum van het rapport van het onderzoek naar de stand van de techniek van internationaal type
28 juni 2021	

Naam en adres van de instantie	De bevoegde ambtenaar
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Kienle, Philipp

1

ONDERZOEKSRAPPORT BETREFFENDE HET RESULTAAT VAN HET ONDERZOEK NAAR DE STAND VAN DE TECHNIEK VAN HET INTERNATIONALE TYPE

Informatie over leden van dezelfde octrooifamilie

Nummer van het verzoek om een onderzoek naar de stand van de techniek

NL 2026709

In het rapport genoemd octrooigeschrift	Datum van publicatie	Overeenkomend(e) geschrift(en)	Datum van publicatie
US 2020272232 A1	27-08-2020	GEEN	
US 2015262424 A1	17-09-2015	GEEN	

WRITTEN OPINION

File No.	Filing date *(day/month/year)*	Priority date *(day/month/year)*	Application No.
SN77566	20.10.2020		NL2026709

International Patent Classification (IPC)
INV. G02B27/00 A61B3/00 A61B3/028 A61B3/11 A61B3/113 G02B30/27 G06F1/16 G06F3/01 G06F3/147 G06K9/00 G06K9/20 G02B30/30 G02F1/1335

Applicant
Rabbit-eyes B.V.

This opinion contains indications relating to the following items:

☒	Box No. I	Basis of the opinion
☐	Box No. II	Priority
☐	Box No. III	Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
☐	Box No. IV	Lack of unity of invention
☒	Box No. V	Reasoned statement with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
☐	Box No. VI	Certain documents cited
☒	Box No. VII	Certain defects in the application
☒	Box No. VIII	Certain observations on the application

Examiner
Kienle, Philipp

Application number

WRITTEN OPINION

NL2026709

Box No. I Basis of this opinion

1. This opinion has been established on the basis of the latest set of claims filed before the start of the search.

2. With regard to any **nucleotide and/or amino acid sequence** disclosed in the application and necessary to the claimed invention, this opinion has been established on the basis of:

   a. type of material:

   ☐ a sequence listing

   ☐ table(s) related to the sequence listing

   b. format of material:

   ☐ on paper

   ☐ in electronic form

   c. time of filing/furnishing:

   ☐ contained in the application as filed.

   ☐ filed together with the application in electronic form.

   ☐ furnished subsequently for the purposes of search.

3. ☐ In addition, in the case that more than one version or copy of a sequence listing and/or table relating thereto has been filed or furnished, the required statements that the information in the subsequent or additional copies is identical to that in the application as filed or does not go beyond the application as filed, as appropriate, were furnished.

4. Additional comments:

Box No. V Reasoned statement with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty	Yes:	Claims	1-25
	No:	Claims	
Inventive step	Yes:	Claims	1-25
	No:	Claims	
Industrial applicability	Yes:	Claims	1-25
	No:	Claims	

2. Citations and explanations

   see separate sheet

WRITTEN OPINION

Box No. VII Certain defects in the application

see separate sheet

Box No. VIII Certain observations on the application

see separate sheet

Re Item VIII

1 **Clarity - certain observations on the application**

Claims 1, 5, 17, 18 and 20 are not clear.

1.1 Device claim 1 and corresponding method claim 18 are disclosing the features *"waarbij de processor (6) is ingericht om een subpixel (13) van het gepixeleerde scherm (3) te relateren aan een corresponderende eerste virtuele pixel (14) van het virtuele beeldvlak (10)"* and *"waarbij de werkwijze omvat: ...het relateren van een subpixel (13) van het gepixeleerde scherm (3) met een corresponderende eerste virtuele pixel (14) van het virtuele beeldvlak (10)"*, respectively. In contrary to the requirements of clarity, only in the characterizing part of device claim 1 and corresponding method 18 the (*underlined*) feature *"een subpixel van het gepixeleerde scherm "* is disclosed without being defined beforehand in the preamble of claims 1 and 18.

1.2 Furthermore, in device claim 1 the feature *"zoals brandpuntsafstand van het oog"* is disclosed in the preamble only as optional feature, but in contrary to the requirements of clarity, in the characterizing portion of claim 1 latter feature is disclosed as an essential feature: *"waarbij de processor (6) is ingericht om een eerste locatie van een virtueel beeldvlak (10) te bepalen, die correspondeert met een eerste kijklocatie van het oog (5) van de gebruiker, door de brandpuntsafstand van het oog van de gebruiker te vergelijken met de eerste kijklocatie"*

1.3 In contrary to the requirements of clarity the subject-matter of method claim 17 differs from the subject-matter of the corresponding (independent) device claim 1 in that it does not disclose the features *"een gepixeleerd scherm (3) met een array pixels (4)", "een processor (6) voor het aansturen van de pixels (4) van het gepixeleerde scherm (3)", "een oogvolgsysteem (7) "* and *"een microlensarray (8) die is aangebracht op het gepixeleerde scherm (3)"*. In other words, the subject-matter of method claim 17 is much broader than the subject-matter of corresponding of indpendent device claim 1, which leads to a different scope of protection.

1.4 It is clear from the description on page 2 (see lines 11-12), page 3 (see lines 12-13 and lines 17-20) and page (see lines 1-2), respectively, that the following features are essential to the definition of the invention:
- *"Each pixel of the pixelated display comprises a number of subpixels, for example three subpixels, for example red, green and blue subpixels."*
- *"The eye-tracking system tracks the position of the eyes of the user andthus the position of the head of the user relative to the display device."*

- *"The processor determines values of subpixels of the pixelated display in order to render a corrected image which appears more in focus for a user with a visual impairment. The processor is adapted to determine the values of the subpixels of the pixelated display based on a location of a virtual image plane."*
- *"The processor is configured for determining a change in viewing location of the eye of the user based on a change in viewing location detected by the eye-tracking system."*

Since independent device claim 1 and corresponding method claim 18 do not contain these features it does not meet the requirement of clarity that any independent (device) claim (and corresponding method claim) must contain all the technical features essential to the definition of the invention.

1.5 In contrary to the requirements of clarity the subject-matter of independent device claim 1 differs from the subject-matter of the corresponding method claim 18 in that latter claim discloses the features *" het vaststellen van een eerste locatie van een virtueel beeldvlak (10) door het vergelijken van de brandpuntsafstand van een oog (5) van de gebruiker met de kijklocatie"* while in claim 1 these features are disclosed in combination with the wording *"bij voorkeur"* as optional features. In other words, the subject-matter of independent device claim 1 is much broader than the subject-matter of corresponding method claim 18, which leads to a different scope of protection.

1.6 The use of terms like *"zoals" (e.g. / for example), "bij voorkeur" (preferably)* or *"bijvoorbeeld",* in claims 1, 5 and 20 has no limiting effect on the scope of the claim.

Re Item V

Reasoned statement with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

Reference is made to the following documents:

D1 US 2020/272232 A1 (LUSSIER GUILLAUME [CA] ET AL) 27 augustus 2020 (2020-08-27)

D2 US 2015/262424 A1 (TABAKA COREY [US] ET AL) 17 september 2015 (2015-09-17)

2 INDEPENDENT CLAIMS

Novelty and Inventive step

Furthermore, the above-mentioned lack of clarity notwithstanding, the following is stated on Novelty and Inventive step regarding independent device claim 1 and corresponding method claim 18.

2.1 CLAIM 1

Document **D1** is regarded as being the prior art closest to the subject-matter of device claim 1, and discloses ***(references in brackets refer to this document)***.

Scherminrichting (100) ingericht voor het weergeven van een afbeelding voor een gebruiker met een visuele beperking ***(see D1: Abstract; Figures 1, 2A-2B; Paragraphs [0002]-[0003], [0010]-[0011], [0110]-[0111], [0113])***, waarbij de scherminrichting omvat:
- een gepixeleerd scherm (120) met een array pixels (804) en waarbij het gepixeleerde scherm (120) bedienbaar is om de afbeelding weer te geven naar een oog van de gebruiker die zich op een kijklocatie ten opzichte van een positie van het gepixeleerde scherm bevindt ***(see D1: Figures 1, 2A-2B, 4-5, 8; Paragraphs [0111], [0113]-[0115], [0119], [0132]-[0134])***;
- een processor (110) voor het aansturen van de pixels van het gepixeleerde scherm (120) om de afbeelding op het gepixeleere scherm (120) weer te geven, waarbij de processor (110) bedienbaar is om informatie over het oog van de gebruiker op te slaan (130), zoals brandpuntsafstand van het oog ***(see D1: Figure 1; Paragraph [0111])***;
- een oogvolgsysteem (1100) ingericht voor het vaststellen van veranderingen in de kijklocatie van het oog van de gebruiker te opzichte van de positie van het gepixeleerde scherm ***(see D1: Figures 1, 13; Paragraphs [0112], [0139]-[0141])***; en
- een microlensarray (800) die is aangebracht op het gepixeleerde scherm (120), waarbij de microlensarray (800) microlenzen (802) omvat die zijn aangebracht in een tweedimensionaal vlak dat parallel aan het gepixeleerde scherm (120) georiënteerd is, waarbij de microlensarray (800) het gepixeleerde scherm (120) bedekt, bij voorkeur volledig bedekt, en waarbij de microlensarray (800) is ingericht om licht uitgezonden door het gepixeleerde scherm (120) naar het oog van de gebruiker in te kijklocatie te projecteren ***(see D1: Figures 2A-2B, 4-5, 8; Paragraphs [0113]-[0114], [0119]-[0121], [0132]-[0135])***,

- ~~waarbij de processor is ingericht om een eerste locatie van een virtueel beeldvlak te bepalen, die correspondeert met een eerste kijklocatie van het oog van de gebruiker, door de brandpuntsafstand van het oog van de gebruiker te~~

~~vergelijken met de eerste kijklocatie, waarbij een virtueel beeld op het virtuele beeldvlak ligt, welk virtueel beeld correspondeert met een beeld dat op het gepixeleerde scherm afgebeeld wordt, waarbij het virtuele beeld waarden van virtuele pixels van het virtuele beeldvlak bepalen~~,

- ~~waarbij de processor is ingericht om een subpixel van het gepixeleerde scherm te relateren aan een corresponderende eerste virtuele pixel van het virtuele beeldvlak door het vaststellen tussen de corresponderende subpixel, de microlensarray, het retina van het oog van de gebruiker, en de eerste virtuele pixel van een lichtpad van een lichtstraal die door de corresponderende subpixel is uitgezonden~~,

- ~~waarbij de processor verder is ingericht voor het vaststellen van een eerste waarde van de corresponderende subpixel van het gepixeleerde scherm door de waarde van de corresponderende subpixel te vergelijken met de waarde van de eerste virtuele pixel~~,

- ~~waarbij de processor is ingericht om de corresponderende subpixel van het scherm te aansturen gebaseerd op de respectieve eerste waarde wanneer het oog van de gebruiker in de eerste kijklocatie is~~,

- ~~waarbij de processor is ingericht voor het vaststellen van een tweede locatie van het virtuele beeldvlak, die correspondeert met een tweede kijklocatie van het oog van de gebruiker, wanneer het oogvolgsysteem een verandering in de kijklocatie van het oog van de gebruiker van de eerste kijklocatie naar de tweede kijklocatie vaststelt~~,

- ~~waarbij de processor is verder ingericht om de corresponderende subpixel van het gepixeleerde scherm te relateren aan een tweede virtuele pixel van het virtuele beeldvlak wanneer het virtuele beeldvlak in de tweede locatie is~~,

- ~~waarbij de processor is verder ingericht om een tweede waarde van de corresponderende subpixel van het gepixeleerde scherm te bepalen door het vergelijken van de waarde van de corresponderende subpixel met een waarde van de tweede virtuele pixel; en~~

- ~~waarbij de processor is ingericht om de corresponderende subpixel van het scherm te aansturen gebaseerd op de tweede waarde wanneer het oog van de gebruiker zich in de tweede kijklocatie bevindt~~.

2.2 The subject-matter of claim 1 therefore differs from this known display device disclosed in D1 in that the processor is configured
- for determining a first location of the virtual image plane, which corresponds to a first viewing location of the eye of the user, by comparing the focal length of

the eye of the user to the first viewing location of the eye of the user, wherein a virtual image is located on the virtual image plane, corresponds to an image to be displayed on the pixelated display and comprises virtual pixels which each have a corresponding virtual pixel value,
- for relating a subpixel of the pixelated display to a corresponding first virtual pixel of the virtual image plane by determining the light path between the corresponding subpixel, the microlens array, the retina of the eye of the user and the virtual image plane,
- for determining a first value of the corresponding subpixel of the pixelated display by comparing the value of the corresponding subpixel to the value of the first virtual pixel,
- for operating the corresponding subpixel based on the respective first value determined for the subpixel when the eye of the user is in the first viewing location,
- for determining a second viewing location of the virtual image plane which corresponds to the second viewing location of the eye of the user, when the eye-tracking system detects a change in the viewing location of the eye of the user from the first to the second viewing location,
- for relating the corresponding subpixel of the pixelated display to a second virtual pixel of the virtual image plane when the virtual image plane is in the second viewing location,
- for determining a second value of the corresponding subpixel of the pixelated display by comparing the value of corresponding subpixel to a value of the second virtual pixel, and
- for operating the corresponding subpixel of the pixelated display on the respective second value when the eye of the user is in the second viewing location;
The subject-matter of device claim 1 is therefore new. Similar like the subject-matter of device claim 1 is in the light of document D1 also the subject-matter of corresponding method claim 18, mutatis mutandis, new.

2.3 The problem to be solved by the present invention may therefore be regarded as
- how to improve the ability of a display device to compenate for visual impairments even when the user moves relative to the display and thus changes the viewing location.

2.4 The solution to this problem proposed in claim 1 of the present application is considered as involving an inventive step for the following reasons:

Document D1 discloses a digital display having a pixelated display with a pixel array, a microlens array, an eye-tracking system and a processor configured for adapting the display on the visual impairments of the viewer based on a fixed viewing location. According to D1 the rendering of an adjusted image is carried out with a computer-based ray-tracing method using an array of light field shaping elements disposed relative to a set of underlying display pixels, that accommodates for the user's reduced visual acuity.
However, the ray-tracing method of document D1 is based on a fixed viewing location of the user and discloses in this respect that "*the casing 3111 may further comprise an eye piece or similar that the patient has to look through, which may limit movement of the patient's eye 3101 during diagnostic and/or indirectly provide a pupil location to the light field renderer*" ***(see D1: Figure 31C; Paragraphs [0250]-[0251])***. As a matter of fact, the ray-tracing method of D1 does not allow to take several viewing locations of the user into account as proposed by the present invention.
In addition, there are no indications in document D1 that would lead the skilled person to modify the digital display and extend the ray-tracing method such as to comprise the distinguishing features listed above, without exercising inventive skills. The other cited document D2 also do not provide such indications. In addition, the person skilled in the art would not combine document D1 with document D2, because document D2 ***(see Abstract; Figure 5B; Paragraphs [0006]-[0008], [0082]-[0086], [0097]-[0102])*** is directed to an HMD capable of depth and focus discrimination using a light-field display system, which address an astigmatism similar to D1 also with a ray-tracing method.

2.5 **CLAIM 18**

In the same way as presented above for the subject-matter of device claim 1 the subject-matter of the corresponding method claim 18 is - mutatis mutandis - also new and inventive.

3 **DEPENDENT CLAIMS**

Claims 2-16 and claim 23 are dependent on device claim 1, claims 18-22 and claims 24-25 are dependent on corresponding method claim 17, and as such also meet the requirements with respect to novelty and inventive step.

4 **<u>Re Item VII</u>**

Certain defects in the application

In addition to the objections raised above, the attention of the applicant is drawn to the following points concerning the different parts of the application documents:

4.1 Amendments relating to the claims:

- they should be drafted in the two part form, which in the present case would be appropriate, and delimited against the most relevant prior art, namely D1-D2;

4.2 Amendments relating to the description:

- the background part of the description should be revised to include a summary of the most relevant prior art with an identification of the document(s) on which said prior art is based, namely D1-D2;

- the description should be brought into conformity with the new claims.

4.3 Furthermore, the applicant should indicate when filing amendments:

- the difference between the subject-matter of the new claim and the state of the art, and the significance thereof with regard to the inventive step involved by the claimed invention;

- where a basis can be found for the amendments in the documents as originally filed.

xxxx